An Interdisciplinary Approach to Assessing, Planning and Managing Urban Rivers in the context of Greater London

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Abstract

Urban rivers present complex management challenges due to the combined natural and anthropocentric factors affecting developed catchments. Planning urban river rehabilitation strategies and measures in parallel with green infrastructure initiatives requires the combined expertise of multi-disciplinary partnerships, encompassing river science and landscape engineering plus community engagement, to deliver integrated and sustainable outcomes. This thesis takes an interdisciplinary approach to investigate the assessment and management of urban rivers, focusing specifically upon the planning of integrated restoration projects for River Thames tributaries within Greater London.

Comparisons of restored and unrestored sites on London tributary rivers at the reach- and catchment-scale explore the versatility of the Urban River Survey method for assessing and communicating contrasts in the bio-physical condition and engineering:habitat associations of heavily modified rivers. A trial of the Ecosystem Services Assessment method for urban river restorations indicates the strengths and limitations of this approach and areas of research need.

Urban river governance investigations and a review of changes in restoration practices over time confirm a decreasing emphasis on channel control and progressively lighter engineering, plus a greater social focus with urban river management becoming increasingly driven by awareness of the symbiosis between rivers and local communities. In some London boroughs partner organisations are developing new links through sustainable development objectives, but connections are geographically inconsistent and typically dependent upon key advocates.

Findings indicate that integrated planning can facilitate interdisciplinary processes through the identification of cross-cutting themes (e.g. climate change) and open knowledge exchange when delivered with appropriate levels of detail. While some disciplinary boundaries are necessary (to define project scope and for task management), socio-ecological benefits may be achieved when these are flexible, permeable and managed responsively in relation to simple overarching goals; and by allowing time for different kinds of knowledge to merge and stimulate new creative and integrated interpretations.

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‘Whoever wades into the world of urban stream restoration and management will be presented with a rich cast of characters who represent different professional cultures and divergent perspectives on urban streams…

..In the last two decades there has been an increasing appreciation by these professional groups of the advantages of working in interdisciplinary teams.’

(Riley, 1998 p.41)

Chapter 1: Introduction - Urban rivers and interdisciplinary approaches

1.1 Introduction

This thesis is concerned with the bio-physical assessment, planning and management of rivers and streams that flow within urbanized catchments. With increasing proportions of the global population (over 80% of the UK and over 50% of world) concentrated in urban environments (United Nations, 2010; Royal Commission on Environmental Pollution, 2007) rivers flowing in developed catchments are increasingly recognised not only as important physical and ecological phenomena, but also having important social significance for humans who live near to these rivers and benefit from their healthy functioning and natural (bio-physical) diversity. However, the engineering of historic river courses within urban areas has reduced their capacity for natural functioning and altered their hydro-morphological and ecological dynamics (Chin 2006, Meyer et al. 2005). When considering the state of urban rivers and opportunities to restore function to damaged systems, it is not only essential to assess and manage the biological and physical elements, but also to integrate the human components of fluvial landscapes within design solutions. As Walsh et al. (2005 p.719) state:

> *‘the success of any attempt to improve the ecological condition of streams in urban areas will largely depend on human attitudes and behaviours within the catchments.’*

1.1.1 Urban rivers: global urbanisation and environmental change

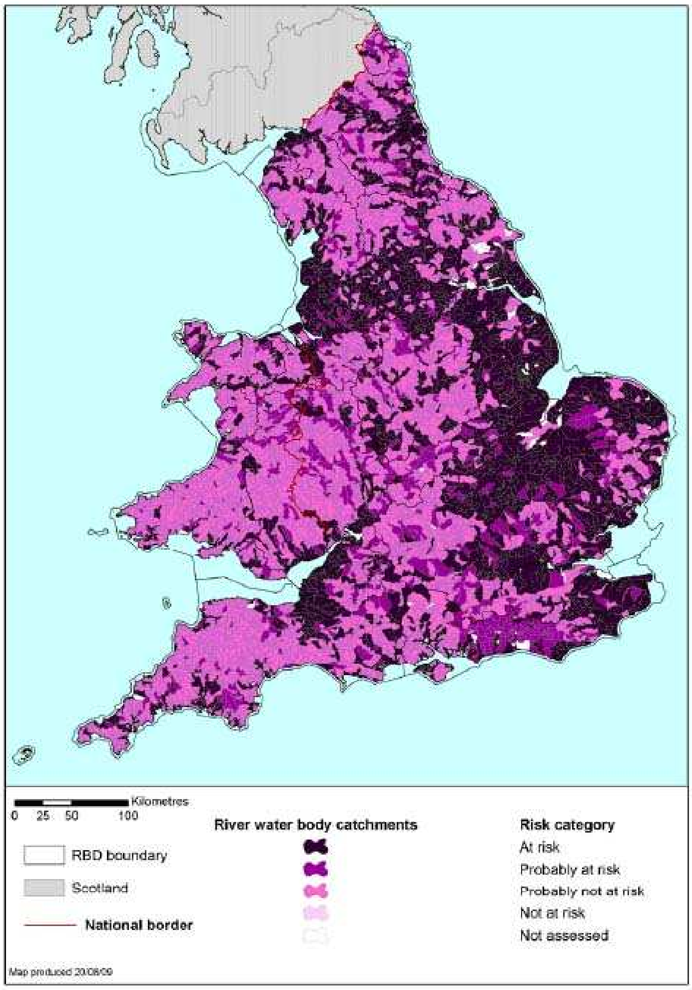
Urban aquatic environments represent one of the most heavily impacted ecosystems with an anthropogenic legacy of engineering modification and pollution. This dates back to early human patterns of settlement beside rivers which provided fresh water for drinking, irrigation and transportation opportunities. The ecological goods and services provided by rivers to people and society underpin a longstanding relationship between humans and aquatic environments. In contrast to typically utilitarian attitudes towards urban water courses, access to well-managed and ecologically healthy watercourses is now becoming an increasingly valued component of urban environments. However, despite the rapid emergence of urban ecology as an integrative research field that encompasses physical, ecological, cultural and socio-economic properties of urban areas, little attention has been devoted to the assessment and sustainable management of urban rivers (Gurnell et al. 2007).

A renewed focus on urban river systems and their management is contributing to the integrated and sustainable development of urban blue and green spaces (GLA, 2011) and the implementation of European legislative drivers such as the EU Water Framework Directive (WFD, EC, 2000). In the UK, increasingly holistic planning guidance aims to emphasise the mutual interdependence of social, economic and environmental considerations (e.g. PPS1 *Delivering Sustainable Development*, ODPM, 2005). Whereas land use planning and the quality of urban natural environments are seen as integral to concepts of ‘sustainability’ and ‘quality of life’ (Meadowcroft, 2000; Van Kamp, 2003), a techno-rational approach to water space design persists within architectural design (Stevens, 2009; New London Architecture, 2008). As well as development and land use pressures, ongoing climatic and pollution impacts continue to drive changes within urban river catchments (Living with Environmental Change partnership, www.lwec.org.uk/). The significance of environmental change in relation to urban watercourses include the urban heat island effect, flash flooding, invasive colonisation by non-native species, point source pollution from fly tipping and (un)licensed discharges plus diffuse surface runoff pollution, that combine to generate multiple impacts and responses within urban river systems.

This thesis is concerned with the present and future of urban rivers; and how integrated management interventions, driven by a range of environmental and social motivations, may enhance and sustain the improved ecological condition of urban river systems, primarily in the context of Greater London, but also for urbanised temperate river systems in general. This chapter provides the rationale and research context for this thesis. Section 1.1 provides a brief background to the research proposal and study areas. The next section (1.2) introduces and defines the different types of disciplinarity and considers these in the context of interdisciplinary research and this thesis. Section 1.3 establishes the significance of interdisciplinary approaches in relation to urban river management issues. The last section (1.4) provides an overview of the thesis aims and objectives and a guide to the contents of the individual chapters.

1.1.2 Urban rivers: UK and Greater London context

The pressures on rivers flowing in urbanised catchments are increasing with the growth of global urban populations (United Nations, 2010) are also evident in the UK. In 2007, Defra estimated 62% of rivers in England to be under morphological pressure (Defra, 2007a) with a high risk of failing to achieve Good Ecological Status (or Potential) under the EU Water Framework Directive (WFD) likely to be due to morphological alteration (White, 2007). The map of surface water bodies at risk of failing WFD standards due to morphological pressure (Figure 1.1) reveals high levels of risk around the Greater London area as well as other urbanised and low lying areas particularly in the east and southeast of England.



© Environment Agency copyright and / or database right 2010. All rights reserved. This map includes data supplied under licence from: © Crown Copyright and database right 2010. All rights reserved. Ordnance Survey licence number 100026380. Some river features of this map are based on digital spatial data licensed from the Centre for Ecology and Hydrology, © CEH. Licence number 198 version 2.

Figure 1.1 Map of river water bodies (Water Framework Directive) in England and Wales: Physical or Morphological Alteration Risk Assessment – Morphological Pressure (Source: www.environment-agency.gov.uk/. Accessed November 2011)

In response to the high levels of channel engineering within the Greater London area, river restoration projects since the mid-1990s have improved up to 22 km of river length within London (Jowit, 2009; Environment Agency et al, 2009). The recently launched London Rivers Action Plan aims to restore a further 15km by 2015 (Environment Agency et al. 2009). This thesis examines the ways in which such restoration works are being delivered under current environmental governance models and investigates how effective current approaches are to achieving and sustaining ecological improvements in urban river systems.

The original motivation for this research project arose from a deep seated interest in aquatic ecosystems and the management of anthropogenic pressures within urbanised catchments consolidated by three main factors:

(i) Environmental consultancy project work involving the application of the EU Water Framework Directive (WFD) and development of River Basin Management Plans, which provided insights into the importance of delivering measures through stakeholder participation and in partnership with practitioners and businesses;

(ii) Research needs identified by Defra and the UK Biodiversity Research Advisory Group (Ferris, 2007) relating to urban hydroecology: linking physical ecological and socio-economic properties of urban areas; plus the need for the development of indicators to help decision makers in planning cost-effective river restorations embedded within integrated urban catchment management (Charles, 2007);

(iii) Conference papers and peer communications highlighting the need for river restoration to involve a wide range of partners in order to achieve the aims of the WFD and sustainable development (White, 2007).

This interdisciplinary research project has been designed to encompass both the physical and human (as social, economic and governance) elements involved in assessing, planning and managing urban rivers in the context of London. The involvement of a wide variety of stakeholders and partners in urban river restoration projects requires the integration of multiple environmental and social objectives relating to planned ecological restoration works. The ways in which diverse partnerships work together, how they communicate to build shared understandings and how restoration projects are financed, emerged as important research themes as the thesis developed. Reflecting the integrated nature of the research, this project has been supported by a combined Research Council studentship award from the ESRC and NERC.

As part of this interdisciplinary research project, four case study sites, located on tributaries of the river Thames within Greater London (namely the rivers Brent, Ravensbourne, Pool and Mayes Brook, shown in Figure 1.2), provided insights into (i) the outcomes for three reaches at different stages of post-restoration recovery and (ii) detailed observation of one project from the pre-construction design and consultation stages through to work beginning on site. Building up on previous research undertaken by Davenport et al. (2001, 2004), Lee (2007) and Robinson (2003), the four case studies together provided the opportunity to contrast different approaches to and outcomes of river rehabilitation and restoration practice over the last 15 years.

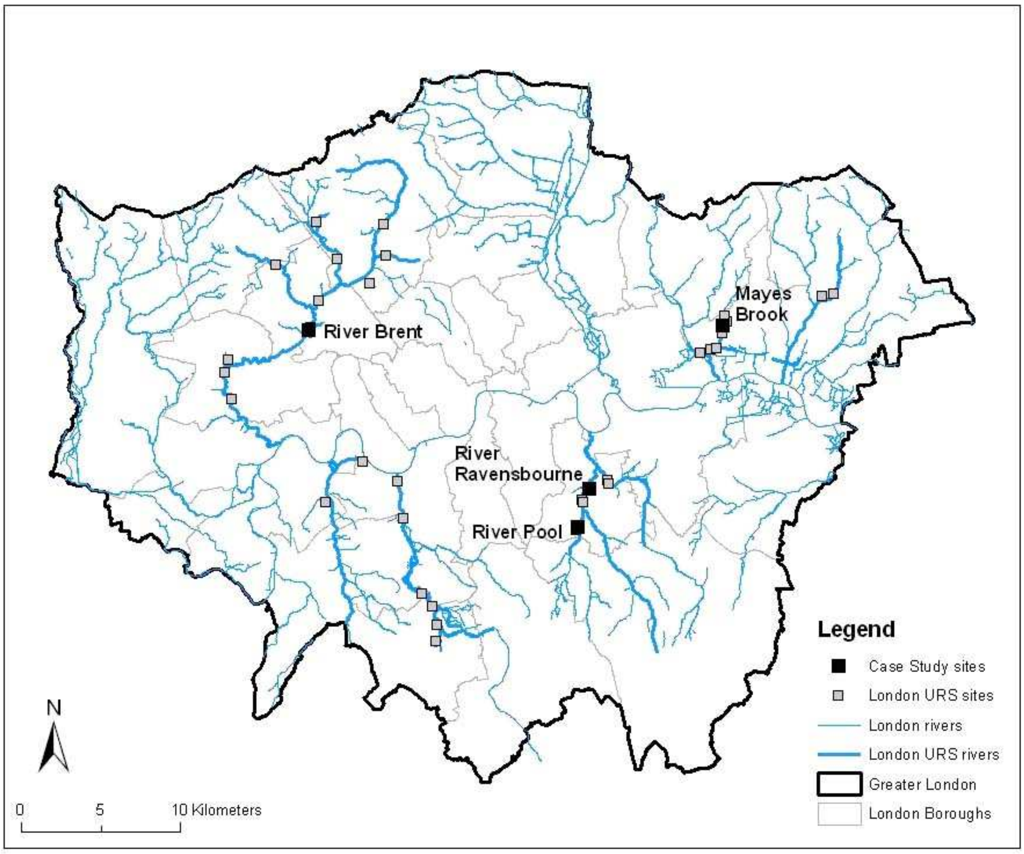


Figure 1.2 Locations of four case study sites in relation to greater London tributary rivers

1.1.3 Sustainable development: integrated management of complex urban environments

Since the 1990s the uptake of sustainable development principles has raised the profile of the importance of working towards integrated approaches which aim to balance social, environmental and economic objectives. The emerging fields of urban, human and reconciliation ecology all offer new insights into the challenges of managing complex urban environments while seeking to integrate understanding of anthropogenic with ecological factors (Pickett et al. 2001; Alberti at al 2003; Rosenzweig, 2003, Dudgeon et al. 2006). The potential supporting role of science research in developing guidance for integrated management practice is associated with the provision of a robust analytical foundation for appraising options and monitoring outcomes; and by simplifying the management of complex systems through the use of key performance indicators (Clark, 2002).

Scientific reduction, systems understanding and approaches to solving complex or ‘wicked’ problems through matrices or models can decrease but not eliminate complexity or uncertainties associated with a range of possible outcomes. A current emphasis on evidence based environmental management, focusing upon robust scientific content and the need for multi-scale perspectives reflects the efforts to integrate and achieve an adaptive and holistic understanding of complex environmental issues. This approach seeks equilibrium between contrasting bio-physical, socio-economic and political perspectives and requires an empathic translation of concepts between the lead protagonists. To achieve sustainable river management, Clark (2002) proposes a linked model that combines measures of socio-environmental sustainability and acceptance of uncertainty within adaptive management and fuzzy decision support systems.

The focus for the use and investigation of interdisciplinary approaches within this thesis is the integrated management of urban rivers. The next sections provide further detail on the research objectives, the context for interdisciplinary research, and significance of interdisciplinary approaches to urban river management.

1.2 Context for an Interdisciplinary Approach

As well as investigating the role played by interdisciplinary approaches in the bio-physical assessment and governance of urban rivers, the nature of the research also pre-determined the application of an interdisciplinary approach, applied through a combination of plural disciplinary methods. A selection of multi- and inter-disciplinary methods were used in parallel within the thesis to gain an understanding of the different research components from a variety of perspectives (as described in Chapter 3).

As a result the thesis soon began to raise questions about the nature of different integrated disciplinary approaches. The ways in which the disciplines are combined in research and in practice was identified as an essential starting point for understanding how multiple objectives can also be integrated via urban environmental management. This section provides an overview of the role of disciplinary integration within the geographical sciences, some examples of interdisciplinary research experiences and recommendations and how these relate to interdisciplinary practices in urban river management.

1.2.1 Definitions of 'disciplinarity' and the nature of interdisciplinary research

> *'Interdisciplinarity is best seen as bringing together distinctive components of two or more disciplines.'* (Nissani, 1997, p.203)

The longstanding value of single or uni-disciplinary approaches, whereby knowledge is organised into separate systems with specific methods by specialist practitioners, undoubtedly lies in their theoretical outputs which underpin the evolution of scientific knowledge, understanding and professional reliability. The demarcation of individual disciplines continues to provide a wealth of specialist knowledge framed within specific critical perspectives and incorporating specialised forms of communication (Helibron, 2003). While the outputs of disciplinary specialism over the last century have delivered unprecedented advances in knowledge and technological capabilities, unforeseen negative outcomes for both the environment and society have also occurred. Advancing recognition of the connectivity and response complexity of anthropocentric impacts and the need for plural disciplinary approaches to address emerging complex environmental issues is now driving increasingly integrated research strategies (Wenger et al. 2009). A review of interdisciplinary research by the British Ecological Society states simply that ‘*no single discipline will be sufficient to address the problems to which society is now demanding answers*’ (Holt and Webb, 2007, p.4). In this context, the development of interdisciplinary research approaches aspires to offer new ways to meet the multiple objectives of urban environmental and river management to support integrated decision making and achieve sustainable solutions (Newson and Large, 2006, Dollar et al. 2007, Clifford, 2007, Petts et al. 2008).

For environmental geographers, interdisciplinarity represents a vital component of applied research and decision support for the management of anthropogenic impacts, biodiversity and habitat conservation, sustainable development and global environmental change. These issues are especially relevant to urban ecology, whereby the complex interactions between anthropogenic and natural environments are brought together through the study of ecological and socio-economic phenomena. Alberti et al. (2003) argue that despite awareness of the need for integration and interpretation of these phenomena by both environmental and social science disciplines, persistent reductionist disciplinary traditions prevent a full explanation of humans and ecological process interactions in human dominated systems.

Although the benefits of interdisciplinary approaches are acknowledged and supported by academics, practitioners and research funding bodies (Nissani, 1997; Meagher, 2005, Demeritt, 2009a), numerous critiques provide examples of the limited success of interdisciplinary research to deliver practical solutions (Demeritt, 2009a, Evans and Marvin, 2006; Petts et al. 2008). For those working at the critical interface of disciplinary boundaries or within the ‘spaces between disciplines’, it turns out that the nature and quality of the interactions between the disciplines can vary widely (Evans and Marvin, 2006; Raco and Dixon, 2007).

Different forms of disciplinary interactions can range from a conjunction of multiple yet discrete disciplinary inputs (multi-disciplinarity) to a fusion and dissipation of disciplinary cultures that transcends disciplinary boundaries to generate novel concepts and solutions (trans-disciplinarity). The latter potentially involves the communication of complex issues with stakeholders to whom disciplinary identities are irrelevant, and can therefore also include the incorporation of non-disciplinary (i.e. experience-based) knowledge (Klein, 2004, Brown et al. 2010a). Falling between these models, interdisciplinarity seeks an integration of components of contributing disciplinary methodologies through the identification of common concerns within real world issues.

However, a range of interpretations for integrated disciplinary models exists within the literature depending upon the research focus of different fields; some examples are provided in Table 1.1.

1.2.2 Experiences of interdisciplinary research

Within environmental research, the literature demonstrates parallel efforts being undertaken by both social and environmental researchers to gain understanding of the interface between the physical and social realms. Within social science research fields, social and political ecology, science and technology studies (STS) and environmental management research describe how science and ecological understanding are inseparable from social frameworks which develop together and in parallel through a co-production of knowledge (Bookchin, 1993; Jasanoff, 1996, Bryant and Wilson, 1998). At the same time physical geography research is also being extended to include the human and socio-economic factors essential to progressing application of an ‘ecosystems approach’ involving stakeholder engagement, ecosystem services assessment and integrated decision making processes (Brierley and Fryirs, 2008; Zhao and Yang, 2009; Everard, 2009, 2011; Everard and Moggridge, 2011).

A surge of interdisciplinary research in the1990s to support the delivery of sustainable urban development demonstrated the Research Councils’ aspirations to produce ‘paradigm-shifting’ research through multi-disciplinary liaisons between scientists working *‘free from discipline or structural barriers’* (Research Councils UK, 2003; 2005; 2011). The emerging challenges of practising interdisciplinary geographical research soon reflected differences between the physical and the human geographical disciplinary epistemological and philosophical traditions. The reality of creating truly integrated processes with tangible outputs of benefit to practitioners and end-users, has been harder to achieve than was initially imagined. However, the experiences of interdisciplinary researchers working on either human or physical geography-led programmes have provided many lessons for future practice as the following examples demonstrate.

Table 1.1 Definitions of the alternative disciplinary approaches within environmental geography

	Disciplinary definitions:		
Author (s)	**Multi-disciplinary**	**Inter-disciplinary**	**Trans-disciplinary**
Petts et al. 2005	Involves a number of different disciplines coming together, but each disciplinary grouping working primarily with their own framings and methods	Involves ‘occupying the spaces between disciplines’ to build new knowledge. Interdisciplinarity involves applications of different sets of skills to physically self-evident problems	A practice that transcends, challenges or renegotiates traditional disciplinary boundaries and in some cases reconstructs them in new positions
Ramadier, 2004	Involves a juxtaposition of different disciplinary theoretical models; highlights different dimensions of studies object by examining subject from plural perspectives	Dialogue between different disciplines constructs a common model; involves the simplification of knowledge and transfers of models between disciplines whereby concepts are appropriated; a theoretical interactionist approach	Involves paradoxes and conflict, seeks to link non-intersecting aspects by articulation and seeking coherence between multiple realities. Presents challenges associated with disciplinary methodological cultures
Klein, 2004		Challenges include communication and differences in methods, work styles and epistemologies	Context specific; the language of stakeholders must also be recognised
Bruce et al. 2004	Approaches subject from different ‘self-contained’ disciplinary perspectives; Involves low levels of collaboration or synergy	Integrates a range of disciplinary perspectives to provide a holistic outcome; cuts across traditional discipline-based academic structures	Focuses on organisation of knowledge around complex heterogeneous domains; set apart from academic disciplinary structures; aims to break down barriers between researchers and stakeholders
	<= Outputs of EU Fifth Framework Programme		
		Focus of EU Sixth Framework Programme =>	

(i) 1990s: Sustainable Cities perspective

Substantial investment in interdisciplinary environmental geography research (estimated at over £30m) during the 1990s through UK Research Councils joint funding packages reflected contemporary UK governmental policy to develop transferable knowledge and links between business and universities with the aim of increasing competitiveness within the UK market (Evans and Marvin, 2006; Department of Trade and Industry, 1998). They included: ‘Urban Regeneration and the Environment’ (URGENT, NERC, Swetnam et al. 2002); the ‘Global Environmental Change Programme’ (ESRC); ‘Towards the Civilised City’ Scoping Study (SERC/EPSRC/AFRC; Berret and Hopkinson, 1991); and ‘Cities and Sustainability’ known as the ‘Red Bus Report’ (EPSRC / ESRC; Clean Technology Unit, 1992) (Figure 1.3).

In their programme review, Evans and Marvin (2006) describe how Research Council attempts to initiate and support interdisciplinary research were broadly unsuccessful as programmes fell back from an initial commitment to interdisciplinarity into multi- or uni-disciplinary working practices. The research outcomes for each programme are described as ‘quasi-interdisciplinary’ with emphases associated with the holding discipline, secondary disciplinary content included as a ‘bolt on’ addition rather than an equal component, and final responsibility for application devolved to the end users. A combination of non-integrated funding pathways and the need to meet academic integrity in terms of rigor are cited as factors contributing to the compartmentalisation of the interdisciplinary strands within each council’s specialism.

(ii) 1999- 2000s: Ecological perspectives

From an ecological research perspective, Turner and Carpenter’s (1999) editorial review of a special edition of the journal *Ecosystems* neatly summarises the challenges for ecologists seeking to undertake interdisciplinary research. Issues which potentially limit interdisciplinary research are summarised as: the lack of existing conceptual frameworks; the requirements for longer time frames for successful outcomes of interdisciplinary team efforts, plus greater attention required by authors and reviewers for writing and reviewing interdisciplinary research papers (Turner and Carpenter, 1999).

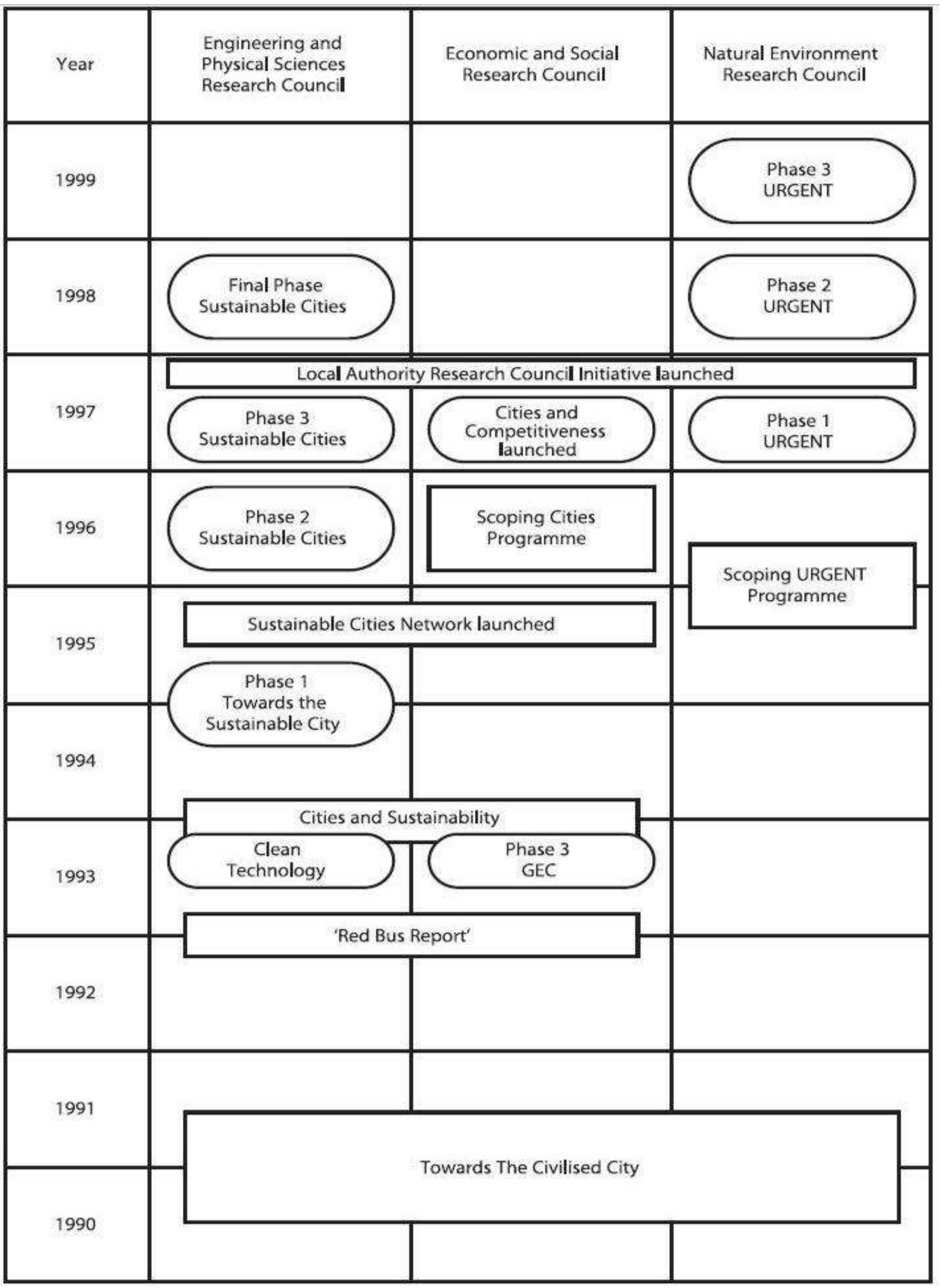


Figure 1.3 Urban interdisciplinary research funding programmes led by EPSRC, ESRC and NERC 1990 – 1999 (source: Evans and Marvin, 2006)

As part of their identification of the 'benefits and burdens' of interdisciplinary research, Pickett et al. (1999) caution against the premature use of critical approaches (in this case, related to ecological academic traditions), which can stifle the constructive progress of research intended to break through disciplinary limitations. Conversely, the benefits of 'bridge building' between diverse sub-disciplines and 'ladder building' between scales are recommended alongside proposals that social science should be integrated, interpreted and assessed in terms of a systems approach: to encompass scales (as relationships in patterns and processes), types of change (such as resilience, resistance, persistence and variability), classifications (of patterns and processes) and to assess human-ecological systems as self-aware, open, non-self-regulating systems, without stable equilibria subject to stochastic change and disturbances (Pickett et al. 1999).

The challenges of integrating across different scales in interdisciplinary river research form the primary focus of Thoms and Parsons (2002) who propose a multi-scale eco-geomorphological framework to guide the study of rivers (Figure 1.4). While the authors do not extend to the inclusion of social elements, this framework provides a useful context for development alongside the recommendations made by Pickett et al. (1999).

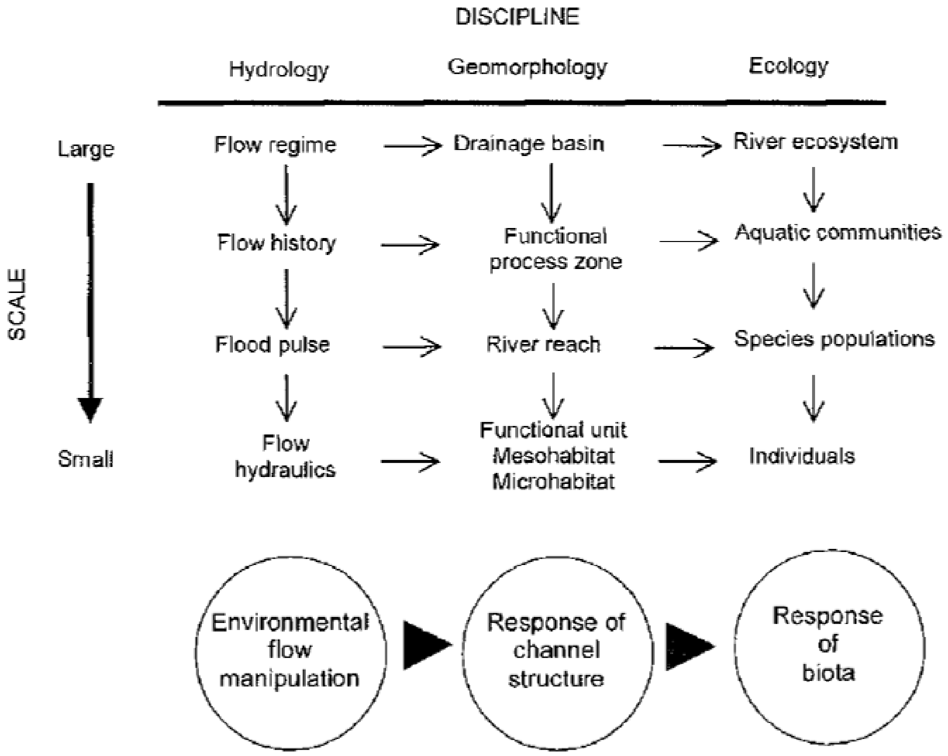


Figure 1.4 Multi-scale relationships between hydrology, fluvial geomorphology and ecology to be considered at an appropriate scale within an ID eco-geo morphological framework. (Source: Thoms and Parsons, 2002)

Extending beyond integration within the environmental sciences, the increasing inclusion of human components within research reflects the importance of understanding the drivers for human engagement to support sustainable river management, especially within densely populated catchments. The experience of Campbell (2005) working as a social scientist with sea turtle conservation biologists again reflects deficiencies in mutual understanding between physical and human geographic disciplines. Avoiding conflicts through differences in expectations is highlighted by Campbell (2005) as fundamental to understanding the value of the contributions social science may bring to environmental science research. Rather than 'bolting on' social science components as a way of improving relations with local communities or enhancing advocacy, Campbell (2005) recommends a better balance in numbers of social and environmental scientists within interdisciplinary teams and the allowance of greater time to build common understandings through the integration of human with environmental science.

(iii) 2000s: Sustainable Urban Brownfield Regeneration: Integrated Management (SUBR:IM) perspective

More recent experience of those involved in the EU Life funded SUBR:IM multi-disciplinary consortium (involving an even balance of engineering and social sciences; academic and industrial participants, to develop interdisciplinary approaches to brownfield regeneration) continue to reflect the differences in research priorities for the physical and social scientists due to '*fundamental incommensurabilities of scope, method, interest, evidential criteria, explanatory warrant and justified inference'* (Catney and Lerner, 2009, p.301). Clear divisions between the engineers and other participants were identified, with the former reported as being more focused on the need for practical solutions and the latter on knowledge accumulation and conceptual refinement, and issues for some within the social sciences associated with '*an inherent suspicion of… servicing the needs of economic interest'* (ibid, p.299-301).

A series of ways forward or generic principles for interdisciplinary research were identified by the reviewing authors at the end of the consortium lifespan. These included the need for extended timescales and work contracts; effective recruitment of researchers willing to challenge disciplinary boundaries with the addition of *'committed translators'* and *'boundary-spanners'*; the development of cross-cutting themes to connect research teams and link across work packages; the constitution of research teams on the basis of equal worth and validity; building research from the 'bottom up' through critical dialogue; and focusing on a single case study to bind the research programme together (Catney and Lerner, 2009).

1.2.3 Recommendations for interdisciplinary research

Despite the partitioned nature of academic research, the literature indicates a broad consensus between social and environmental scientists that (i) segregation along the physical–human divide represents a limiting factor; (ii) multidisciplinary perspectives are essential in the production of holistic integrative solutions (Raco and Dixon, 2007); and (iii) within geography there is significant creative potential for cross cultural exchanges of ideas (Nissani, 1997). However, combining or interpreting research and knowledge across disciplinary boundaries requires flexibility, new skills and resources to develop new types of accessible outcome. In researching constructive approaches to interdisciplinary research, six problematic themes were identified:

1. *Disciplinary integrity and identity:* reflects fears that disciplinary robustness may be weakened when findings are challenged by other disciplines. For some academics this was associated with a lack of regard for applied research and perceived instrumentalism, especially where partnerships with industry provide sponsorship and objectives to research (Petts et al. 2008; Fenneman, 1919). Perceived risks are associated with loss of academic rigor (manifested in relation to publication and career pathways); achieving necessary depths of specialist knowledge within academic structures; and a ‘sense of belonging’ which may be ‘easily eroded’ in pursuit of interdisciplinary breadth (Demeritt, 2009a).

2. *Different standard methodologies:* for example, predominant analytical methods used by physical (mainly quantitative) and human (mainly qualitative) geographies present barriers to communication, translation and shared knowledge.

3. S*pecialised language:* resulting in non-congruent meanings and differences in the framing of questions by different disciplines (Bracken and Oughton, 2006; Harrison et al. 2008). The co-existence of contrasting definitions for common terminology were reported as problematic within the multidisciplinary SUBR:IM consortium (Catney and Lerner, 2009), as Pickett et al. (1999) note, even common language can hide divergent assumptions.

4. A *pre-conditioned partitioning of roles* between the social and physical sciences whereby multidisciplinary teams gravitate towards an unequal partnership of (physical) ‘technical potential’ combined with (socio-political) ‘problem solving’. In this scenario the main role of the latter was to remove potential barriers to technical potential

resulting from of oversimplification of social scenarios in comparison to the scientific goals (Petts et al. 2008).

5. *Perception of hierarchies*: reflecting fears for social scientists that differences in the framing of issues could lead to potential dominance by ‘physical technical’ interpretations accompanied by lack of understanding of socio-technical complexity. For example, placing quantitative technical ‘hard’ science above the qualitative value orientated ‘soft’ science components; or interpreting technical physical scientific components’ as having an ‘upstream’ position which sets up the outcomes for the ‘downstream’ social analyses to occur (Demeritt, 2009b).

6. *Limited dissemination* of outputs to end users and connectivity with those delivering policy ‘on the ground’ e.g. within local authorities. In many cases, the evidence shows that interdisciplinary research outputs have not been truly integrated or applied, limiting broad dissemination and inaccessibility of results (Evans and Marvin, 2006).

While the literature engages mainly with the practicalities of these issues, in many cases they reflect contrasting perspectives of knowledge seen through the positivist and constructivist theoretical underpinnings of the different scientific philosophies and methodologies. In addressing these commonly identified themes, recommendations are also found across a range of source material. These include: (i) creating cross-cutting collaborations to reshape conventional disciplinary boundaries; (ii) the use of common language and innovative engagement strategies to achieve effective communication; (iii) a new style of coordinated management between research funding bodies to attract researchers across disciplinary boundaries; and (iv) the dissemination of results to end users, ensuring that policy needs are met (Evans and Marvin, 2006; Catney and Lerner, 2009). The replacement of disciplinary hierarchy by adjacency, with each discipline required to relax the rigidity of their own approach to allow new ‘*polyvocal’* methods to emerge, is also recommended by Evans and Randalls, (2008, p.581).

The combined recommendations identified here and within section 1.2.2 are brought together in Table 1.2 in relation to the six themes highlighted above to provide an indication of potential ways forward for the successful application of interdisciplinary approaches in relation to this thesis.

Table 1.2 Risks and recommendations of interdisciplinary research identified by Evans and Marvin, 2006; Evans and Randalls, 2008; Pickett et al 1999; Campbell, 2005

	Challenges / Risks					
Recommendations	**1. Disciplinary integrity and identity**	**2. Different standard methodologies**	**3. Specialised language**	**4. Perception of hierarchies**	**5. Partitioning of roles**	**6. Dissemination / connectivity**
1. Reshape conventional disciplinary boundaries through cross-cutting collaborations	✓			✓	✓	✓
2. Attract researchers across disciplinary boundaries through a new style of coordinated management between research funding bodies	✓				✓	
3. Balanced numbers of environmental and social scientists	✓			✓	✓	
4. Use common language and innovative engagement strategies, allow the use of polyvocal methods		✓	✓	✓		✓
5. Develop conceptual frameworks for interdisciplinary approaches, replacing hierarchy with adjacency		✓	✓	✓	✓	
6. Longer time allowances to build common understanding and greater attention by authors and reviewers	✓	✓	✓	✓	✓	✓
7. View social sciences in terms of systems approach to encompass: different scales, types of change and classifications		✓		✓	✓	
8. Expectation management	✓			✓	✓	✓
9. Disseminate results to end users, ensuring that policy needs are met.			✓			✓

1.3 The significance of interdisciplinary approaches for urban river issues

> *'In the modern river environment, successful restoration and management demands the integration of viewpoints and expertise of many types of physical and social scientist'* (Clifford, 2007, p.3)

The issues emerging from interdisciplinary research also provide important sign posts for the integration of urban ecological and socio-environmental components specific to urban river assessment, planning and management. The significance of interdisciplinary approaches to urban rivers is closely associated with managing the legacy of anthropogenic impacts and environmental pressures described in section 1.1 (e.g. engineering, diffuse and point source pollution, climate change and invasive species), which have resulted in complex sets of issues for urban river practitioners to address.

Current policy drivers e.g. the London Rivers Action Plan (Environment Agency et al. 2009), Rivers and Stream Habitats Action Plan (www.lbp.org/), Water Framework Directive (2000/60/EC), Making Space for Water (Defra, 2005) and the London Plan (GLA, 2011), provide timely mechanisms for the facilitation of improvements to heavily modified river systems in urban catchments. Their advocacy of a range of restoration and enhancement opportunities for urban rivers, especially where these coincide with public open greenspaces and accessible riparian corridor routes, makes this a critical time for understanding how integrated solutions can be delivered most effectively through current environmental governance models.

1.3.1 Interdisciplinary approaches in aquatic sciences and river restoration

The literature review in Chapter 2 takes an historic overview of the progression of scientific understanding and assessment of urban rivers from predominantly single to integrated perspectives, through the growing realisation of the interconnectedness of natural systems and the anthropogenic impacts upon them. Within ecological science a systems approach has been used to describe organisms and their environments since the late 1960s (Clarkson, 1970; Brierley, 2008). This approach depends upon information from a combination of disciplinary knowledge bases to shed light upon the complex processes occurring within the natural environment. Hydrological science also provides links between geomorphology and river ecology, encompassing a wide range of spatial and temporal dimensions and as dynamic flow regimes adjust river channel morphology and the habitats of aquatic organisms that in turn drive feedbacks through interactions with the ecological and hydrological processes of the river system (Gurnell, et al. 2000).

Dollar et al. (2007) argue that an interdisciplinary framework involving ecology, hydrology and geomorphology is essential for understanding the multi-causal relationships that occur within rivers between different environmental bio-physical components. This understanding has evolved to integrate different temporal and spatial scales and hierarchies to explain the relationships, boundaries and pathways within terrestrial and aquatic ecosystems, involving a complex range of biological and physical processes. Increasing understanding of bio-physical aquatic habitat has driven research in hydro-ecology and bio-geomorphology (Gurnell et al. 2000; Vaughan et al. 2009). The emergence of new interdisciplinary theories (reviewed in more detail in Chapter 2) has influenced the emerging integrated assessment methodologies of the 1990s and 2000s as well as river and catchment management practices.

The advantage of combining information from different environmental disciplines is that they can easily find a common ground in their terminology, quantitative methodological and analytical approaches, which can subsequently be applied to adaptive management strategies (Newson and Large, 2006). By contrast the conceptual, methodological and linguistic differences between physical and social sciences are repeatedly cited as obstacles to finding common understanding and transferring knowledge between disciplines (Holt and Webb, 2007).

The urgency of identifying successful ways to integrate human components within urban river catchments is currently highlighted by the increasing opportunities to carry out combined river and riparian restoration works in the public open greenspaces which exist along urbanised river floodplains. In these locations ample opportunities and drivers now exist to enhance biodiversity and other environmental services provided by rivers and floodplains. However, an academic understanding of the drivers for sustainable ecological development and stewardship involving local stakeholders is lagging behind.

Over the last 20 years, river restoration practices have evolved from those based primarily on geomorphic classification (Doyle et al. 1999) to integrative approaches encompassing the principles of sustainable development, by integrating ecological, social and economic factors into decision making and delivery. This has followed a wider shift in river management from engineering based ‘command and control’ styles of intervention, to a more holistic ecosystem approach which takes ‘integrative river science' and a landscape or catchment scale perspective as its guiding principles (Brierley and Fryirs, 2008). Within urban landscapes the opportunities for river restoration often occur in public greenspaces located along river corridors and within river flood plains, thus emphasising the imperative need to integrate social with environmental objectives to ensure sustainable ecological outcomes.

1.3.2 Integrating blue and green spaces

The increase in integrative approaches to river restoration (Brierley and Fryirs, 2008) reflects broader changes in urban environmental governance as parks and green spaces become integrated through the establishment of green corridors and grids, building connectivity often along watercourses (Van der Windt and Swart, 2008; James et al. 2009; GLA 2011). Recent changes in London park management include the incorporation of unmown wildflower meadow areas, combining a reduced maintenance regime with ecological benefits. Where rivers flow through or along the perimeter of public green spaces, restoration works reconnecting rivers to their floodplains have included the construction of sustainable urban drainage systems in the form of swales and artificially enhanced flood storage depressions, enabling the development of naturalised and biodiverse areas of urban wetland (e.g. on the River Quaggy at Sutcliffe Park in the London Borough of Greenwich (www.therrc.co.uk/)).

A new focus of ecological research known as 'reconciliation ecology' is raising the profile of urban natural spaces as vitally important intra-urban havens for biodiversity providing resilience for a wide range of species as well as improving the well being of human city residents (e.g. physical and psychological health, cultural, and aesthetic benefits: Rosenzweig, 2003; Dudgeon et al. 2006; Francis et al. 2011).

In the context of London environmental governance, aspirations of the recently updated London Plan include the expansion of the East London Green Grid to the west and south encompassing additional river corridors that provide essential green infrastructure within the metropolis (GLA, 2011). However, despite the clear spatial synergy between the East London Green Grid and Blue Ribbon Network demonstrated within the London Plan (GLA, 2011), the uptake of wider catchment scale management remains obstructed by administrative borough boundaries which fail to reflect either environmental or human catchment boundaries in relation to urban blue and green spaces (Figure 1.5).

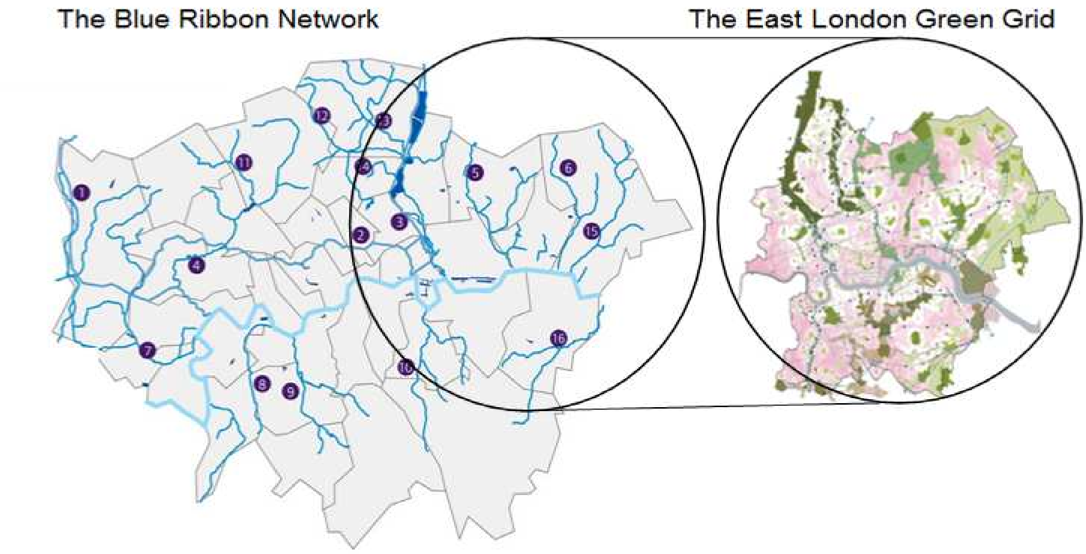


Figure 1.5 Comparison of spatial synergy between London's watercourses and green infrastructure as illustrated by the London Plan: Blue Ribbon Network and the East London Green Grid, Strategic Planning Guidelines. (Adapted from: GLA, 2011; 2009)

1.3.3 Stakeholder involvement and urban river partnerships

As noted in the previous section (1.3.2), a major challenge for integrated catchment management is the fragmentation of urban river systems between administrative boundaries and the partitioned ownership of riparian land between public and private landowners. While the Environment Agency (as the regulatory authority for England and Wales) holds statutory powers to deliver their duties in relation to water quality, flood risk management and aquatic ecology, they also need to work in partnership with riparian owners to balance ecological with sustainable development objectives.

In the case of urban rivers, riparian owners may be individuals or private, voluntary or public sector bodies. Where land is publically accessible, riparian ownership will typically belong to the local authority and the range of interests in the river, riparian and associated open space will be diverse including: parents with young children (formal and informal play), dog and recreational walkers, naturalists, historians, anglers, sports teams (formal and informal), joggers, teenagers and youth services, local residents or office workers etc. The synergies or tensions that may exist between the variety of different urban river and green space users can be dynamic and fluid as the distribution of people and activities vary spatially and temporally in relation to the same place and interactions are defined by users as individuals and groups.

As a result, when changes to shared public spaces are proposed, a variety of different interpretations will be generated according to different users' experiences of the river and adjacent riparian spaces. This plurality of interests may be complimentary or conflicting. The potential benefits of partnership working within urban environmental planning processes include the opportunity to represent and bring together different interests including the diverse perspectives of park users to generate a shared or 'living vision' that can operate within a flexible framework (i.e. one which can accommodate the interests of all stakeholders and through which all interests can recognise and respect the legitimacy of each others). Increasing engagement by environmental scientists in social science arenas is beginning to consider socio-cultural components within integrated river management research by investigating the role of a 'vision statements' to generate insights into how such communication tools may integrate and translate objectives into action (Gregory and Brierley 2010).

1.4 Discussion of aims and objectives and guide to other chapters

The relevance of interdisciplinarity and interdisciplinary models to this thesis lies within the potential to gain insights into the role of urban river assessment tools and dynamics of integrated urban river planning and management involving multi-disciplinary partnerships. Lessons learned through integrated research (section 1.2) carry valuable information for integrated river management practices. The boundaries between disciplines, whether conceptual or methodological, represent different philosophical outlooks or ways of interpreting common phenomena that are equally valid and also coexist within society through different non-disciplinary framings. Therefore, identifying ways to work with and through boundaries will be an essential tool for future integrated socio-environmental research and management practices.

This thesis presents the argument that working to develop interdisciplinary approaches is essential in building common ground, but that for some aspects of urban river restoration integration, uni- and multi-disciplinary models will continue to dominate due to practical limitations associated with time and communication tools. However, by developing understanding, the role of each model within the constraints of project delivery will support the development of more effective interactions between key actors and shed light upon new ways to deliver ecologically and socially successful and sustainable urban river restoration outcomes.

1.4.1 Interdisciplinary and other flexible working disciplinary models

As our understanding of complex integrated systems develops it appears that multi and interdisciplinary approaches are vital to academic framing and research, while different forms of disciplinarity have the flexibility to adapt in the context of a variety of applications to different types of integration need. The importance of transdisciplinarity is also emerging along with the need to facilitate communication and interpretation beyond disciplinary frameworks e.g. for stakeholder communication (Klein, 2004, Brown et al. 2010b). Awareness of the need for disciplines to incorporate knowledge, generated through a range of associations and sources, represents a powerful reflexive aspect of integrated research and offers academics the opportunity for novel feedbacks between the different models of combined disciplinary research (Figure 1.6).

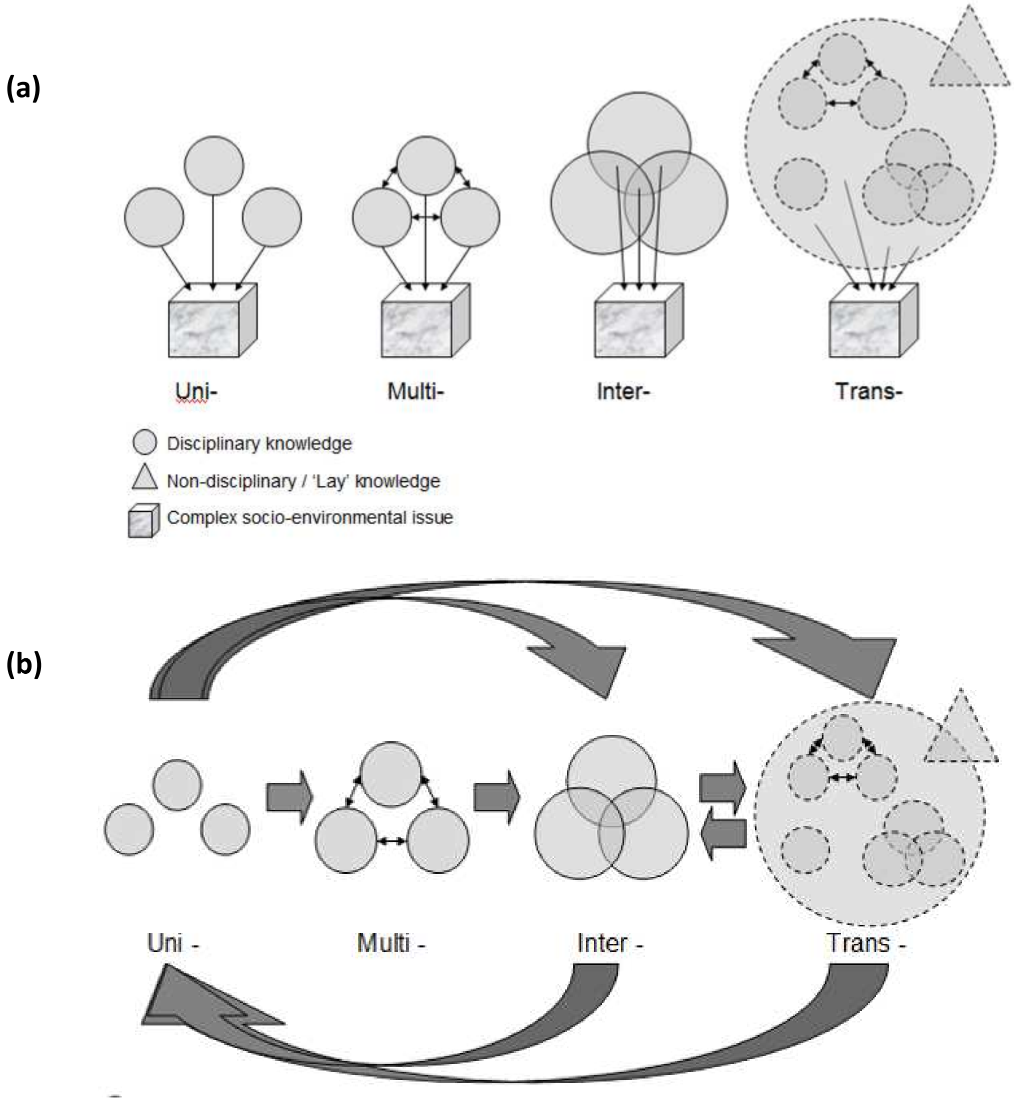


Figure 1.6 Relationships between (a) the different configurations of uni-, multi-, inter- and trans- disciplinary approaches to complex environmental problems; and (b) the potential feedbacks between different disciplinary configurations. (Adapted from Ramadier, 2004 and Klein, 2004)

In the interdisciplinary research context, the literature repeatedly highlights the need to build upon the commonalities of each discipline and continue building bridges to explore new ways of working together. Nissani (1997, p.214) uses the metaphor of the ecosystem to describe the components of a thriving academic community which typically nurtures '*specialists and generalists, diversity and interconnectedness'*. Complementary to that perspective, the specific nature of urban environments is regarded by Pickett et al. (2001) as an integrated socio-ecological landscape whereby patch dynamics can also be used to explain social structures and dimensions in contemporary urban ecological systems perspective. Thus, building on the qualities of the heterogeneity of multi-disciplinary associations may present the most positive and constructive starting point to begin interdisciplinary research.

In contrast to all the limiting factors cited within this chapter, Gandy (2008) recognises that by articulating interrelationships, different insights can be incorporated through scientific explanation to produce coherent and mutually intelligible outputs. Differences in language and culture, and the use of different sets of skills by different disciplines, were seen by many as being enriching for communications and coordinated research (Petts et al. 2008). Overall recognition of the need for interdisciplinary training for researchers and the necessity of lifelong learning due to interdisciplinary unpredictability are also acknowledged by Hoey and Philo (2004), and Evans and Randalls (2008). Based upon the evidence discussed within this chapter, a summary of the essential components of interdisciplinary approaches are summarised in Box 1.1.

Box 1.1 The primary qualities of interdisciplinary approaches

Interdisciplinary approaches:

- have no clear framework or formula for operation;
- involve the joint efforts of multi-disciplinary team members and therefore take longer to find common understandings;
- require translation and interpretation between different languages and value systems
- require open and constructive approaches to find novel solutions rather than premature critical obstructions.

1.4.2 Aims and objectives

The overall aim of this research project is to enhance understanding of interdisciplinary approaches to assessing, planning and managing changes in the biophysical condition of urban rivers. In order to meet this aim, the wider context of sustainable environmental governance which seeks to integrate ecological and social objectives for urban rivers in public greenspaces is also investigated.

The research design developed from a series of objectives that were identified to structure activities and to enhance knowledge of:

(i) interdisciplinary approaches to assessing changes in the bio-physical condition and ecosystem services of urban rivers brought about through restoration works;

(ii) the main drivers for the ecological and socio-environmental improvement of urban river ecosystems and ecosystem services;

(iii) how partnerships work together to combine multiple objectives and plan and deliver ecologically successful and cost-effective urban river restorations;

(iv) the financing and valuation of urban river restoration.

To meet these objectives the research design includes a combination of environmental and social science methods (described in Chapter 3) summarised below in Table 1.3 below. Taking a multi-method approach will provide diverse perspectives and a ‘thick description’ of the subject material by drawing upon different disciplinary approaches.

Table 1.3 Research objectives and methods used within thesis

Research Objectives	**Chapter(s)**	**Method(s) applied**		
		Environmental	**Social**	**Interdisciplinary**
Gain understanding of the use of an interdisciplinary approaches to assessing urban rivers	4, 6, 8	Urban River Survey	Observation and interviews	Case Studies; Ecosystem Services Assessment
Gain understanding of policy and planning context and drivers for urban river restoration in London	5, 6		Discourse analysis; Observation and interviews	Case Studies
Gain understanding of how multi-disciplinary partnerships come together to plan and deliver urban river restoration projects	6, 7, 8		Observation and interviews	Case Studies
Valuation and cost effective delivery of urban river restoration and ecosystem service enhancements	4, 6, 7		Observation and interviews	Case Studies; Ecosystem Services Assessment

1.4.3 Thesis Structure

The structure of this thesis reflects the research design (outlined in Table 1.3) and the wide range of environmental, social and integrated elements incorporated in this thesis to meet the research objectives.

Chapter 2: Literature Review explores the breadth of challenges that urban environmental planners, managers and decision-makers face in order to deliver holistic (i.e. combined and objective) solutions to complex ‘real world’ planning problems in the context of urban conservation and regeneration strategies. The diversity of literature reviewed provides extensive knowledge of environmental and social aspects relating to the assessment, planning and management of urban rivers and the foundation for the thesis arguments. As the thesis progresses the linkages between these aspects emerges and the interdisciplinary arguments are developed.

Chapter 3: Methodology provides the rationale for the investigative design and scope of the multi method approach applied within this thesis. The chapter also introduces the study areas at the regional and local scales.

Chapters 4 to 8 each address different aspects of urban river assessment, planning and management from different perspectives.

Chapter 4: Results (I) - Integrated assessments of urban rivers in Greater London applies and analyses Urban River Surveys from a sample of London tributaries to the river Thames. It explores the utility of the survey and perspectives derived from it at region, through catchment to stretch scales, as a suite of tools to support river assessment and restoration decision-making. The results of an Ecosystem Services Assessment of the primary urban river restoration case study are also presented, as an alternative form of integrated socio-environmental assessment currently significant to urban environmental management.

Chapter 5: Results (II) - Policy discourses presents a policy discourse analysis considering the challenges of integrating objectives for urban rivers through current policy drivers. An overview of the mechanisms of the WFD and River Basin Management Plans are provided alongside other environmental and planning policy relevant to urban river restoration.

Chapter 6: Results (III) - Policy into practice considers the historic evidence for urban river restoration practices within London through practitioner data collated by the River Restoration Centre and London Rivers Action Plan. A desk study of the individual case study sites is presented in the context of their management history, objectives for restoration and outcomes in relation to a time line of restoration practices within London.

Chapter 7: Results (IV) – Environmental governance of urban rivers in Greater London presents the results of social methods to investigate the environmental governance of urban river restoration through multi-disciplinary partnership. This chapter examines some emerging issues in relation to partnership life cycle stages and also considers funding structures and processes for urban river restoration in the context of the main case studies.

Chapter 8: Results (V) – Integration of objectives for urban river restoration provides a detailed investigation into the processes involved in the integration of environmental and social objectives within the main case study partnership. The perceived challenges of objective integration arising for different partners are explored and compared to a series of proposed solutions and research observations, which also provide evidence for emergent interdisciplinary processes and positive socio-environmental outcomes.

Chapter 9: Synthesis specifically draws together the interdisciplinary theme through a review and discussion of the environmental, social and integrated findings presented in chapters 4 to 8 in relation to the research questions identified in Chapter 2. These results are compared to the theoretical context for interdisciplinary approaches described in Chapter 1. The chapter closes with final suggestions for further research.

Chapter 2: Literature review - Interdisciplinary approaches to urban river assessment, governance and valuation

2.1 Introduction

Urban rivers may be found flowing through bio-diverse ecological corridors or sterile concrete tunnels. In either case, they contribute many essential services to society. Yet these working aquatic systems are widely undervalued and subjected to numerous damaging impacts including channel engineering, catchment development, polluting discharges and over-abstraction (Walsh et al. 2005). Paradoxically, historic perceptions of urban rivers as drainage and waste disposal systems, contrast strongly with contemporary architectural uses of water to enhance development aesthetics and re-image cities (Pinch and Munt, 2002). High levels of appreciation for water features in public spaces; enthusiasm for angling, water-sports and water-dependent species e.g. kingfishers and otters, also underlie modern perspectives of water bodies as valued constituents of working and recreational environments.

Efforts to return urban rivers from damaged drainage systems to ecologically healthy and functioning landscape elements through restoration and enhancement projects (see Box 2.1) are now generating a growing body of evidence to demonstrate the socio-environmental benefits of bio-physical interventions. However, the literature relating to urban river assessment, planning and management appears relatively disconnected, limiting progress towards the sustainable management of the most heavily impacted rivers. This is especially relevant where urban rivers adjoin public open spaces and offer substantial opportunities to coordinate river, riparian and floodplain restoration efforts, thereby enhancing regulatory (e.g. flood control), supporting (e.g. biodiversity) and cultural (e.g. recreational, educational) ecosystem services for local communities.

One of the challenges of this interdisciplinary research project has been the breadth of literature coverage required to shed light upon the multi-disciplinary components relevant to the planning and management of urban river restoration. In particular, to gain an understanding of previously unfamiliar social science theories, a broad range of social science literature was scoped to identify theoretical frameworks regarding multi-disciplinary partnership and potentially problematic areas for the urban river practitioner community.

Box 2.1: Restoration, rehabilitation and enhancement: definitions and distinctions

Ongoing debates exist within the published literature concerning the correct terminology to use for river improvement works that aim to reverse the impacts of physical change on river stretches as a form of 're-naturalisation' of river systems (Newson and Large, 2006). From an ecological perspective, the term 'restoration' implies a full structural and functional return to a pre-impacted physical form or ecological state (Brookes and Shields, 1996), which is not feasible within an urban catchment. The term 'rehabilitation' is found to be more appropriate in many cases (Schmidt et al. 1998; Downs and Thorne, 1998) and is the favoured term in many countries (e.g. Australia, Brierley and Fryirs, 2008).

In the UK, use of the term 'restoration' has become an established tradition and the norm for UK discourses, reinforced through the title of the leading independent advisory organisation the River Restoration Centre (RRC). In the context of London rivers, the Rivers and Streams Habitat Action Plan Steering Group led by the Environment Agency, produced guiding definitions (and targets) for river restoration and enhancement to clarify the difference for London river practitioners (Environment Agency, unpublished 2011)

> **Definition of Restoration:** Measure that results in a significant increase in diversity of hydromorphological features and or improved floodplain connectivity and the restoration of river function through essential physical or biological processes, including flooding, sediment transport and the facilitation of species movement. (*Current target: 15 km by 2015.*)
>
> **Definition of Enhancement:** In-stream habitat enhancement, channel-narrowing, removal of weirs or barriers, establishment of buffer zones through riparian fencing or tree planting, and wetland creation within 10 metres of the channel. Also appropriate agreement and implementation of ongoing planned management activity. Enhancement projects include restoration work. (*Current target: 100km by 2015.)*

In line with the EA guidance on London river 'restoration' provided above, the term 'restoration' is used throughout this thesis to refer to *the reinstatement of biophysical and ecological function* rather than to any imagined pre-impacted physical form or ecological state.

This chapter reviews the literature relating to the assessment, planning and management of urban rivers in relation to the restoration of bio-physical and ecological functioning and ecosystem services provisions. The deep-seated connections between urban river environments and human activity necessitate a multi-disciplinary approach, and therefore this review encompasses a relatively diverse literature including river assessment, environmental governance and ecosystem services valuation.

To set the context for urban river assessment, section 2.2 begins by tracing the development of scientific knowledge of river system functioning: from single to multi-disciplinary understanding of the bio-physical components of aquatic ecosystems (section 2.2.1). A brief consideration of river classification methods (section 2.2.2) precedes a more comprehensive overview of the progression of river assessment approaches since the 1960s (section 2.2.3). A more detailed review of urban river assessment methods and their relevance to urban river restoration follows in section 2.2.4. Challenges and choices for river assessment emerging from the literature and with direct relevance to urban rivers are highlighted in section 2.2.5. The main findings from the literature regarding river assessment and urban rivers are summarised in section 2.2.6.

The literature reviewed in section 2.3 provides a broad background to the environmental governance of urban rivers. To begin, section 2.3.1 provides a brief historic overview of urban river governance in London and the establishment of sustainable development principles, setting the context for modern urban environmental governance issues. Based upon academic and grey literature sources, a set of management challenges and issues for urban rivers in London are defined. Section 2.3.2 next investigates the characteristics of partnership and partnership working to gain an understanding of the structures and processes behind the environmental governance of urban river restoration. In section 2.3.3 further understanding of different types and approaches to integration is gained through literature relating to sustainability discourses. The challenges of integrating social and environmental components are considered further in relation to complexity theory in section 2.3.4. These sections aim to discover how different disciplinary perceptions raise ‘boundary issues’ which can affect integration and therefore the effectiveness of interdisciplinary approaches when working at the interfaces between the environment and society.

Section 2.4 is concerned with the valuation of urban river environments. Of the extensive literature relating to ecological economics, ecosystem approaches and services, this section includes a selection of contextual literature and discourses relevant to urban river and greenspace valuation, and to financing urban river restoration. A brief history of the evolution of ecological economics and an overview of different approaches to valuing urban river ecosystem services (sections 2.4.2 and 2.4.3) provide the context for selected examples of urban river and greenspace Ecosystem Services Assessments (section 2.4.4). The generation of evidence currently being gathered through Defra's Evidence Investment Strategy provides some early opportunities to highlight 'lessons learned' of relevance to urban river valuation.

Section 2.5 closes this chapter with a brief synopsis of the main points arising from the review of literature in sections 2.2 to 2.4 (section 2.5.1) and introduction to the research questions addressed in this thesis (section 2.5.2).

2.2 River Assessment: for non-urban and urban rivers

Whilst the evolution of bio-physical and ecological river assessment approaches has paralleled increasing scientific knowledge of geomorphology and ecology, the history of *urban* river assessment is relatively brief. This section focuses primarily on the development of conceptual understandings and assessment methodologies relating to bio-physical river functioning to set the context for a review of the discourses surrounding urban river assessment. As such, the river assessment literature is considered not only in relation to increasing knowledge regarding bio-physical river functioning, but also social aspects of human influences upon and interactions with urbanised river systems.

2.2.1 Conceptual understandings of river functioning

Progress towards the integrated understanding of river systems has been underwritten by a series of conceptual landmarks. A succession of key papers mark significant steps towards understanding river system functioning: from linear to lateral connectivity concepts (Horton, 1945; Vannote et al. 1980; Junk et al. 1989); singular to multidimensional processes (Leopold and Wolman, 1957; Ward, 1989); encompassing variations in both temporal and spatial scales (Schumm and Lichty, 1965; Frissell et al. 1986). These concepts elucidate the complex functioning of river ecosystem processes. A timeline of emerging concepts indicating the dimensions, scales and linkages concerned (Table 2.1) provides an overview of how understandings of fluvial system functioning have evolved.

This section does not attempt to give an exhaustive account of the evolution of knowledge of river function and processes, classification and assessment methodologies (see Lorenz, 1998; Downes and Barmuta, 2002; Gordon et al. 2004; Brierley and Fryirs, 2008). However, to set the context for the investigation of interdisciplinary approaches to urban river assessment, the guiding principles underlying the evolution of integrated assessment methodologies are first acknowledged, then considered in terms of their influence upon management objectives and practices for urban rivers.

2.2.1.1 Single focus

Dating back over 5000 years BP, the earliest evidence of river manipulation, associated with the provision of drinking and irrigation water, are found in Mesopotamia and Egypt (Hassan, 2003; Mays et al. 2007). In the UK, the earliest evidence of reservoir dam construction (dated around 80AD) coincides with the Roman occupation (Keys, 1998). In recent history, significant river-human interactions, dominated by ‘command and control’ approaches are characteristic of enlightenment science and industrial modernity (Allan, 2003a, Brierley and Fryirs, 2008). These views supported the belief that nature could be dominated and manipulated for human benefit with no ‘cost’ and minimal consideration of the potential ecological impacts of engineering works e.g. channelization and impoundment. The cumulative effects of these early approaches are now better understood as the precursors of the currently observed bio-physical impacts on aquatic ecosystems.

Advances within the disciplines of fluvial geomorphology, hydrology and ecology, (summarised in Table 2.1) demonstrate a convergence and development of interdisciplinary understanding of river systems and the following brief synopsis of these conceptual developments describes their succession.

i. Geomorphological

From the mid-1900s advances in the physical understanding of fluvial systems were closely associated with engineering works undertaken to support the provision of environmental goods (e.g. drinking water); and services (e.g. flood regulation, agricultural land drainage and irrigation; navigation, goods transportation) for human populations (Allan, 2003b; MA, 2005a). Pure scientific research (dating back to the

Table 2.1 Chronological summary of emerging concepts in river understanding and their relationship with the four dimensions of fluvial systems and human impacts

CONCEPTS	**Author**	**Longitudinal**	**Temporal**	**Vertical**	**Lateral**	**Human**
Stream order / drainage ranking	Horton, 1945	✓				
Hydraulic geometry approach: linking channel form to discharge	Leopold and Maddock, 1953	✓				
Zonation of fish communities	Huet, 1954, 1959	✓				
Concept of different river flow regimes	Pardé, 1955		✓			
River channel patterns: Straight, braided, meandering	Leopold & Wolman, 1957	✓				
Slope-discharge relationships for river patterns	Lane, 1957	✓				
The hyporheic zone	Orghidan, 1959			✓		
Dynamic equilibrium	Hack, 1960		✓			
Zonation of macro-invertebrates & fish	Illies & Botosaneaunu, 1963	✓				
Fluvial process-form dynamics	Leopold, Woman & Miller, 1964	✓	✓	✓	✓	
Time, space & causality / dynamic equilibrium & time scales	Schumm & Lichty, 1965	✓	✓	✓	✓	
The ecology of running waters	Hynes, 1970, 1975	✓				
Drainage basin form and process	Gregory and Walling, 1973	✓	✓	✓	✓	
Nutrient recycling	Webster et al, 1975	✓				
Instream flow needs	Orsborn and Allman (eds.), 1976	✓				
The fluvial system	Schumm, 1977	✓	✓	✓	✓	
Resource Spiralling	Wallace et al, 1977; Newbold et al., 1981, 1982; Elwood et al., 1983	✓				
River Continuum Concept	Vannote, et al, 1980	✓				
Groundwater and stream ecology	Hynes, 1983			✓		

Serial discontinuity concept	Ward & Stanford, 1983	✓				✓
Tributaries modify the river continuum concept	Bruns et al., 1984	✓			✓	
Patch dynamics concept	Pickett & White, 1985		✓			
Nested-hierarchical framework for stream habitat classification	Frissell et al, 1986	✓	✓	✓	✓	
Stream hydraulics	Statzner & Higler, 1987	✓				
River-floodplain connectivity	Amoros & Roux, 1988				✓	
Role of disturbance in stream ecology	Resh et al., 1988		✓			
Riparian ecotones concept	Naiman et al, 1988				✓	
Patch dynamics in lotic systems	Pringle et al, 1988		✓			
Flood pulse concept	Junk et al, 1989		✓		✓	
Four dimensional lotic systems	Ward, 1989	✓	✓	✓	✓	
Ecosystem perspective of riparian zones	Gregory et al., 1991	✓	✓	✓	✓	
Hyporheic corridor	Stanford & Ward, 1993	✓		✓	✓	
Riverine productivity	Thorp & Delong, 1994	✓				
Flood disturbance regime & succession of riparian plant communities	Décamps and Tabacchi, 1994		✓		✓	
Hydraulic food-chain models	Power et al., 1995		✓			
Hierarchical patch dynamics paradigm	Wu, 1995		✓			
Fluvial hydrosystem approach	Petts and Amoros, 1996	✓	✓	✓	✓	
Catchment hierarchy approach	Townsend, 1996	✓				
Indicators of hydrologic alteration	Richter et al., 1996		✓			
Stream health concept	Meyer, 1997	✓	✓	✓	✓	✓
The natural flow regime	Poff et al., 1997		✓			

Process domains & the river continuum	Montgomery, 1999	✓			✓	
Flow pulse vs. flood pulse concept	Tockner, Malard & Ward, 2000		✓		✓	
Geomorphic thresholds in riverine landscapes	Church, 2002	✓	✓		✓	
Flow-sediment-biota relations	Osmundson et al., 2002	✓	✓	✓	✓	
Processes and downstream linkages of headwater streams	Gomi et al., 2002	✓				
Ecological effects of drought perturbation	Lake, 2003		✓			
Network dynamics hypothesis	Benda et al., 2004	✓				
Effective discharge for ecological processes	Doyle et al., 2005		✓			
River styles framework	Brierley et al, 2002	✓			✓	
River ecosystem health concept	Zhao & Yang, 2005a	✓	✓	✓	✓	✓
Vegetation as a driver of physical- & bio-complexity in fluvial corridors	Gurnell et al., 2005; Corenblit et al., 2007	✓	✓	✓	✓	
Riverine ecosystem synthesis	Thorp et al, 2006	✓	✓	✓	✓	
Fish environmental guilds	Welcomme et al., 2006					
Urban river restoration planning concept	Zhao et al, 2007					
Hydrologic spirals	Poole et al., 2008	✓		✓		
Ecological limits of hydrologic alteration	Poff et al., 2009		✓			

1800s) was dominated by investigations into landscape creation and evolution, and led to the emergence of theories relating to river-formed features and fluvial geomorphology. For example, the concept of ‘stream order’ was first addressed in 1834 by Julian Jackson, and was subsequently developed, reordered (by Horton, 1945) and refined by several geomorphological scholars, and is still used to rank channels within drainage basins (Oldroyd and Grapes, 2008). Ideas of equilibrium or quasi-equilibrium within river systems were implicit in early research (Leopold and Maddock, 1953; Leopold and Wolman, 1957), revealing associations between fluvial processes (river discharge, sediment transport regimes) and river channel size, geometry and planform responses. The concept of dynamic equilibrium was developed further by Hack (1960) to explain river channel adjustments to erosional landscapes across time and space under varying geological conditions.

(Dis)equilibrium concepts have since underpinned further developments in fluvial geomorphological theory. In particular, Schumm and Lichty (1965) placed them into a timescale context; Melton (1958) introduced the concept of ‘relaxation time’ in geomorphic systems during which landforms adjust to changes in processes; Schumm and Beathard (1976) and Schumm (1977) proposed the concepts of geomorphic thresholds and complex responses of channel morphology to changes in controlling processes. The conceptualisation of geomorphic landscape timescales introduced by Schumm and Lichty (1965), provided valuable communication tools through their proposals that landform adjustments followed dynamic (i.e. progressive change), steady state, and static equilibrium pathways according to cyclic (e.g. 10^6 yrs), graded (e.g. 10^2-10^3 yrs) or static (e.g. 10^{-2}yrs) time scales; and that the landform development factors involved can be either dependent or independent depending upon the temporal and spatial scales being considered. Since the 1960s, an enormous volume of research has focused upon scale-dependency of geomorphological systems, on the mathematical structure of process-form relationships (non-linear, multivariate), and, increasingly, on the inherently chaotic, self-organising nature of natural systems in response to perturbations (e.g. Philips, 1999).

In a spatial context, Schumm’s ‘Fluvial System’ (1977) provides a linear subdivision of an idealised catchment, describing three sections as: an upper or headwater area (of net sediment erosion), a mid section (where erosion and deposition are approximately balanced), and lower section (where sediment deposition dominates). Subsequent catchment-scale research, focused on sediment budgets and dynamics, also emphasises the morphological consequences of human influences on water and sediment catchment transfers. Key publications include Wolman (1967) for urban development; Trimble (1983) for impacts of agriculture; Petts (1984) for dam construction; and Brookes (1989, 1995) for the physical impacts of, responses and alternatives to river channel engineering.

From the 1980s onwards, recognition of the importance of fluvial geomorphology to the understanding of river processes and responses to human physical interventions soon led to the application of geomorphological knowledge to river habitat conservation, flood defence operations and water resources management works within the National Rivers Authority during the 1990s (Brookes, 1995). Specific interests in bank erosion and sediment transport regimes became included in research and development agendas and the physical rehabilitation of rivers was identified as a viable river management objective. The over-riding principle of geomorphology to work with nature (rather than against it) is underpinned by qualitative evaluations of channel change based on a holistic view of river processes and functioning at the catchment scale (Brookes and Sear, 1996).

Recent emphases upon the value of landscape and catchment-scale perspectives of river management owe much to fluvial geomorphological theory. However, the extent to which geomorphological principles are successfully applied to urban river restoration planning and management is undocumented. As described above, the understanding of ‘cause and effect’ processes developed rapidly alongside advancing post-industrial technology and globalisation, enabling international recognition of the extent of morphological damage across numerous river systems.

ii. Biological

Running in parallel with geomorphology, early biological conceptual understanding of aquatic systems had its origin in fisheries and their supporting ecology. Descriptions of the zonation of fish and macro-invertebrate communities highlighted key physical attributes of aquatic habitat in the upper, mid and lower reaches of rivers, in terms of water temperature and flow velocity (Huet, 1954; Illies and Botosannneanu, 1963; Roux et al. 1992). These associations clearly indicate fundamental connections between biological function and productivity and physical habitat conditions. The Trent Biotic Index (Trent River Board, 1960) and Biological Monitoring Working Party (BMWP) system (BMWP, 1978), provide examples of biological assessment methods developed in recognition of the links between biota and water quality.

The conceptualisation of the spiralling transportation of nutrients downstream by aquatic filter feeders by Wallace et al. (1977), lead the way for Vannote et al. (1980) to develop their River Continuum Concept, which described the linear continuity of the river system through the distribution of macro-invertebrate communities in relation to energy inputs and resource partitioning. This concept, developed in the context of North American aquatic ecosystems within forested catchments, describes a linear continuity from headwaters to lowland reaches based on changes in energy inputs, invertebrate functional groups (collectors, shredders, grazers etc) and related primary productivity and respiration ratios. It has been widely adopted as a general model for undisturbed heterotrophic stream systems dependent upon allocthonous inputs, but its inaccuracies for application to deforested autotrophic headwater catchments were soon raised by Winterbourn et al. (1981). Issues of discontinuity within impacted systems also provide insights for rivers physically modified by engineering works whereby material or energy flow obstructions result in impacts upon the ecological structure of biotic communities downstream and disruptions to the river continuum (Ward and Stanford, 1983).

2.2.1.2 Multiple focus

i. Bio-physical integration

Increasing awareness of the sensitivity of interconnected and complex river ecosystems to diverse human impacts has led to the development and increased use of ecological indicators in river assessment (Minshall, 1988). Early awareness of the connectivity between species and landscapes was publicised through Carson’s ‘Silent Spring’ (1962) which highlighted the risks of remote cause and effect impacts upon biodiversity through human activity. Also Lovelock’s Gaia Theory (1979, 2000), by describing the Earth as a single complex ‘living’ organism with multiple self-regulating feedback mechanisms, captured public attention and coincided with the beginnings of a political paradigm shift in the 1980s towards greater awareness and support for environmental policies.

During this time, the literature reveals significant conceptual advances regarding the spatial and temporal relationships between the inputs, throughputs and outputs of river systems in terms of: (dis)continuities (Vannote et al. 1980; Ward and Stanford, 1983) and habitat patch dynamics in streams and riparian ecotones (Pickett and White, 1985; Pringle et al. 1988; Naiman et al. 1988). The recognition of hydrological connectivity between rivers, water bodies and floodplains, first described by Amoros and Roux (1988), was further developed to include ecologically essential links between in-channel reaches and the riparian zone through the Flood Pulse Concept (Junk et al. 1989). Ward's (1989) four dimensional framework of stream function: longitudinal; lateral, vertical and temporal, conceptualises the complex multi-dimensional nature of lotic systems, providing the foundation for the Fluvial Hydrosystems concept (Petts and Amoros, 1996) which emphasises the importance of the interactions between fluvial dynamics and biological processes over the three spatial dimensions and at different time scales. Growing awareness of the need for integrated systems perspectives that can be interpreted at different spatial and temporal scales has since formed the basis for the establishment of hierarchical interpretations for the terrestrial and aquatic sub-disciplines that inform environmental management.

Further complex inter-relationships defining river productivity: in terms of water quality, energy budget, physical structure and flow are provided by Stalnaker (1979), and developed further through the Hierarchical Catchment Framework of Frissell et al. (1986). These complex physical and biological theories form the basis for the holistic integration of multidisciplinary elements and understanding of rivers as ecosystems (Dollar et al. 2007; Thorp et al. 2006). Moves towards an overarching ecological assessment of rivers has led to conceptually inter-disciplinary approaches that perceive bio-physical aquatic variables as supporting elements for the ecological systems, and include the consideration of physical processes which sustain habitats and organisms (Brierley et al. 2002). While much research has centred on the optimal habitat requirements for target species, providing the basis for river condition evaluations, e.g. Instream Flow Incremental Methodology and PHABSIM modelling (Bovee, 1978, 1986), more recently, consideration of the diversity and dynamism of bio-physical habitat, including the crucial roles of aquatic and riparian vegetation as engineers of river morphology is adding to knowledge of processes supporting a healthy river ecology (Gregory et al. 2003, Gurnell et al. 2005, Corenblit et al. 2007).

New insights into the relationships between flow hydraulics, fluvial geomorphology, and aquatic ecology began to influence river management practices during the 1980s (Newbury, 1984; Maddock, 1999), with physical habitat being first included as a basic element of river assessment in England and Wales in the 1990s (National Rivers Association, 1992). The ecological focus has been further strengthened through the requirements of the EU Water Framework Directive, with increasing attention on understanding and modelling relationships between hydrology, geomorphology and ecology (Poff et al. 2009) and widespread interest in incorporating driftwood and living vegetation into river rehabilitation efforts (e.g. Gerhard and Reich, 2000; Collins and Montgomery, 2002; Stromberg et al. 2007).

In the UK, substantial research efforts towards ecosystem approaches sponsored by Defra since 2005 clearly signal the importance of ecological perspectives to future environmental management (http://www.defra.gov.uk/environment/natural/ecosystems-services/ecosystems-approach/, section 2.4) The rationale underpinning of the application of an ecological approach lies in the ability of biotic indicators to reflect the condition of other supporting environmental variables that may be impacting either singly or in combination upon the river itself. Literature regarding the influence of these concepts upon river classification and assessment are reviewed further in sections 2.2.2 and 2.2.3.

ii Anthropo-environmental and socio-environmental integration

While insights derived from river science research continue to develop integrated understandings of fluvial systems, developing concepts to elucidate urban river processes demands the integration of bio-physical knowledge with anthropogenic or ‘anthropo-environmental’ catchment influences (Box 2.2). In particular, a rising awareness of the ecological and functional impacts of channelization and hard engineering approaches upon river systems, for example in North America (Kissimmee River) led to a growth of knowledge relating to anthropogenic physical impacts and alternative approaches to managing river channels (Brookes, 1985, 1989, 1995; Downs and Gregory, 2004).

New approaches emerging from the field of urban ecology include the concept of ecosystem and river ‘health’ (Schaeffer et al. 1988; Rapport et al. 1998; Pickett et al. 2001; Brierley and Fryirs, 2008), whereby the wellbeing of complex environmental systems is framed in familiar anthropomorphic terminology thus facilitating understanding of river systems and services for non-river-scientists (Meyer, 1997, Boulton, 1999). The relatively new ‘river health’ concept encapsulates the idea of a living functioning river system to be monitored and maintained, and embraces the human ecological element through an ecosystems view of the catchment as a ‘societal watershed’ (Meyer, 1997).

Further challenges associated with the consideration of social elements within urban catchments, also introduce the need to consider the interests and culture of local communities within a much broader scope of river health assessment (Pahl-Wostl, 2007; Holt, 2009) and suite of communication tools (Brierley, 2009). These ‘socio-environmental’ (Box 2.2) approaches are strongly reflected in the WFD methodology which requires that stakeholders are involved not only through consultation processes but also in terms of delivering additional voluntary measures that may prove fundamental in meeting WFD aims to prevent deterioration and bring about improvement in the ecological status or potential of water bodies (Orr et al. 2007).

2.2.2 River Classification

As basis for empirical study, the naming and ordering of complex system characteristics through classification provides a structure for the categorisation of types and baseline for (i) reference conditions; (ii) comparison with undamaged systems and (iii) communication between (non)specialists (Gurnell et al. 1994). As such, classification systems underpin UK water regulation and determination of compliance with environmental standards e.g. for water quality; and provide the foundation for ecological assessment under the EU Water Framework Directive (WFD; 2000/60/EC).

Box 2.2 Definition of terms

Anthropo-environmental – refers to the integration of human (anthropogenic) interventions or interactions with natural environmental systems (e.g. Pirazizy, 1992)

Socio-environmental – refers to the integration of society and social factors with environmental components or objectives in relation to outcomes of interventions (Hinchliffe, 1996)

Although usually empirical (using semi-quantitative or qualitative methodologies), when considered alone, classifications carry limited value for process interpretation. However, in a river management context, they provide valuable tools for communicating condition, comparisons between sites and over time, to assess responses to impacts, including restoration works (Gordon et al. 2004). In relation to urban river systems, aspects (i) and (ii) are also problematic, as these systems are inherently damaged. Therefore, urban river classification systems demand relative rather than reference-based comparative approaches.

Maddock (1999) highlights links between the development of physical habitat classifications and increasing demands for river restoration and fisheries enhancements appraisal methodologies. Examples shown in Table 2.2 reflect the shift from single to multiple perspectives (highlighted in section 2.2.1) and the purpose driven focus of individual classification methods. For example, the Rosgen channel classification approach is widely used in the US as a basis for channel engineering design (Lave, 2008), however the inappropriate use of fixed, static classes to design ‘restored’ channels for continuously adjusting (i.e. dynamic) systems has been criticised by fluvial geomorphologists (e.g. Simon et al. 2007). Concerns that grouping rivers into types with similar average morphological and sediment characteristics carries the risk of misrepresenting the formative processes occurring within river systems, are supported by evidence of river engineering ‘failures’ involving negative or unexpected outcomes (Lave, 2008, Downs and Kondolf, 2002). Additionally, emphasis upon ecological assessment also requires attention to be paid to the overall condition of dynamic systems at a range of scales (Vaughan et al. 2009).

Table 2.2 Examples of classification approaches using single and multiple indicators, for a variety of management purposes

Indicator(s)	**Classification subject / Management focus**	**Methodology**
Macro invertebrates	Water quality General biological quality	BMWP and ASPT scores RIVPACS; Wright et al.1993
Landforms and sedimentary structures	River and channel types	Rosgen, 1994
Flow velocity and substrate information	Hydraulic habitats of aquatic organisms	PHABSIM, Bovee, 1982
Bank form, sedimentary structures and biological attributes	Bio-physical habitat assemblages and overall river habitat quality	River Habitat Survey (RHS) Raven et al. 1997

The WFD classification method is used to assess ecological and water quality, with hydrology and geomorphology described as supporting elements for the primary biological (fish, macro-invertebrate, macrophyte) indicators (www.wfduk.org/). For heavily modified water bodies (assessed in terms of ecological *potential*), classification begins with the identification of the physical pressures upon water bodies resulting from modifications or artificial characteristics, before assessing the associated adverse ecological impacts. These combined assessments then go forward to the objective setting stage (UKTAG, 2008).

Urban river classification is a relatively recent development with different international variants. Examples include classifications based upon water quality in Japan (Miyabara, et al. 1994), diatoms in Australia (John, 2000) and physical habitat in the UK (Boitsidis et al. 2006; Davenport et al. 2004). The UK developed Urban River Survey (URS) combines information on the channel engineering, channel boundary materials, vegetation and physical habitats to produce composite classification scores to generate a Stretch Habitat Quality Index, which may be used to define management options.

2.2.3 River assessment: An international perspective

Building upon the growth of river science knowledge and awareness of human impacts on river systems (section 2.2.1), corresponding advances in integrating approaches to river assessment have also emerged over the last 20 years. As a foundation to the investigation of interdisciplinary approaches to *urban* river assessment, this section reviews the literature to identify the extent to which international river assessment methods demonstrate the integration of multi-disciplinary anthropo-environmental or socio-environmental inputs (see Box 2.2 for definition of terms).

2.2.3.1 Drivers for river assessment

The percolation of the integrated ecological understanding of aquatic systems through the various fields of river management (i.e. fisheries, conservation, water resources, flood defence), is now reflected at an international level by far-reaching policy changes (e.g. United States: Green Infrastructure for Clean Water Act of 2009; Europe: EU Water Framework Directive (WFD), 2000; Australia: National Water Initiative (NWI), 2004; South Africa: National Water Resource Strategy, 2004; Convention on Biological Diversity, 1992). In response to these high level changes, national and regional level regulatory agencies are taking forward novel assessment protocols and strategies to integrate their systems of biological, physical and chemical data collection, e.g. SERCON, Boon, (1996, 2002); also Williams et al. (2005). In recognition of the international agreement regarding sustainable development (Rio Declaration / Agenda 21, UNCED 1992), new frameworks and integrated assessment strategies also demand socio-economic information to reflect the importance of humans as stakeholders in the present and future well-being of river systems (Newson, 2007). A further conceptual leap was marked by the international Millennium Ecosystem Assessment and elaboration of the concept of Ecosystem Services as '*the benefits people obtain from ecosystems'* (MA, 2005a).

In England and Wales, river assessment for legislative compliance has been coordinated by national regulatory body, the Environment Agency (EA). Their procedures, driven by government policy, support the sustainable use of water; protection of water quality and drinking water supplies (Water Act 1996; Water Supply (Water Quality) Regulations, 2000); protection of aquatic habitat '*of biodiversity conservation importance'* via UKBAP targets (UKBAP, 1994; CROW Act, 2000) and for flood risk management purposes (Making Space for Water consultation Defra, 2005; Flood and Water Management Act, 2010). A broad review of UK policy discourses of relevance to urban river management is the subject of Chapter 5.

While integrated or catchment management strategies have been operational since the 1990s, (e.g. Catchment Management Plans, Local Environment Agency Plans) actual assessment methodologies have remained divided between water quality (General Quality Assessment, GQA scores), water resource quantity (Catchment Abstraction Management Strategies, CAMS) and river habitat structure (River Habitat Survey, RHS) (Logan, 2001). Within urban catchments, opportunities to combine social with environmental goals, for example by restructuring floodplain landscapes to reduce crime through spatial design, are demonstrated in London by recent restoration projects on the rivers Ravensbourne (QUERCUS, LB Lewisham, 2008) and. Brent (Tockyngton Park, Eden and Tunstall, 2006). Such integrated objectives demand the additional assessment of stakeholder perceptions and priorities and introduce new challenges in achieving consensus regarding optimal conditions (Karr, 1999).

2.2.3.2 River assessment methods: an international overview

An extensive scoping of international river assessment methods, identified through internet based searches (October 2008 – July 2010), provides the basis for an historic overview of river assessment approaches (Table 2.3). The timeline of river assessment methods illustrates the shift from single to multiple integrated approaches, the geographic distribution of assessment innovations and introduction of many new methods from the 1990s onwards.

Table 2.3 International examples of river habitat assessment methods

Year	Assessment method	Continent
1960	Trent Biotic Index (Trent River Board, 1960)	EU
1972	Irish Water Quality Rating (Q-Rating) / EPA Ireland (Flanagan & Toner, 1972)	EU
1978	Biological Monitoring Working Party (BMWP) Scoring System (*links to geomorphological reach type as depositing / eroding* (BMWP, 1978)	EU
1979	Habitat Quality Index (Binns & Eiserman, 1979)	EU
1981	Index of Biotic Integrity / US (Karr, 1981)	USA
1982	Instream Flow Incremental Methodology (IFIM) US Fish & Wildlife service, PHABSIM / USA (Bovee, 1982; 1998; Milhous et al. 1984)	USA
1983	Average Score per Taxon (ASPT) included with BMWP *used for 1990 National River Pollution Survey* (Armitage et al. 1983; Walley & Hawkes, 1997)	EU
1983	Pool Quality Index / USA (Platts et al. 1983)	USA
1984	River Corridor Survey (RCS, National Rivers Association, 1992)	EU
1987	Invertebrate Community Index (ICI) / US (Ohio EPA, 1987)	USA
1989	Rapid Bioassessment Protocols (US EPA)/ USA (Plafkin et al. 1989; Barbour et al. 1999)	USA
1989	Qualitative Habitat Evaluation Index - QHEI / Ohio (Rankin, 1989)	USA
1992	RCE: Riparian, Channel And Environmental Inventory for small streams in the agriculture landscape (Petersen 1992)	EU
1992	Rapid Stream Assessment Technique (RSAT) / Washington, USA (Galli, 1992, 1996)	USA
1993	State of the Rivers Survey / NSW & Queensland Australia (Anderson, 1993)	AUZ/NZ
1993	Bioenergetics models (Hill & Grossman, 1993) *flow requirements for trout and dace habitat*	EU
1993	River Invertebrates Prediction and Classification: RIVPACS / UK (Wright et al. 1993; 1998; 2000)	EU
1993	USGS National Water Quality Assessment (NAWQA) – Stream habitat assessment protocol (Meador et al. 1993)	USA
1994	South African Scoring System (SASS) (Chutter ,1994)	AFRICA
1994	Reconnaissance level survey (Thorne & Easton, 1994)	EU
1994	Integrated geomorphological approach for appraisal of river projects (Downs & Brookes, 1994)	EU
1994	River Channel Morphology Assessment (RSPB et al. 1994) *developed by Brookes for modified rivers*	EU
1994	Instream Biological Assessment Monitoring Protocols: *Benthic Macroinverts* / Washington, USA (Plotnikoff, 1994)	USA
1994	Rosgen guide for classification & assessment / USA (Rosgen, 1994)	USA
1994	Index of Habitat Integrity (IHI) (Kleynhans, 1996).	

1995	Fluvial Audit (Sear et al. 1995)	EU
1995	SIGNAL - Stream Invertebrate Grade Number Average Level (*simple biotic index adapted from ASPT*) / Australia (Chessman, 1995; 2001; 2003)	AUZ/NZ
1996	Geomorphic River Styles / Australia (Brierley 1999)	AUZ/NZ
1996	River Habitat Survey / UK (Fox et al. 1996, 1998; Raven et al. 1997; Walker et al. 2002)	EU
1996	Habitat mapping (Maddock & Bird, 1996)	EU
1996	System for Evaluating Rivers for Conservation: SERCON/ UK (Boon et al. 1996; 1998; 2002)	EU
1996	Integrated river aquifer simulation model (IRAS) Loucks et al. 1996)	USA
1996	SEQ-MP (Fr) *Physical Quality Assessment* (Agence de l’Eau Rhin-Meuse, 1996)	EU
1998	South African River Health Programme (*Index of Stream Geomorphology*)/ South Africa (Rowntree & Wadeson, 1998)	AFRICA
1998	Integrated Habitat Assessment System (IHAS) / South Africa (McMillan, 1998)	AFRICA
1998	South African ‘Building Block Methodology' (BBM)(King & Louw, 1998)	AFRICA
1998	Urban Stream Habitat Assessment (USHA) / NZ (Suren et al. 1998)	AUZ/NZ
1998	HABSCORE (salmonid habitat)(Milner et al. 1993; 1998)	EU
1998	Stream Reconnaissance Survey / UK (Thorne 1998)	EU
1998	Catchment Baseline Survey (in *River Geomorphology: A practical guide)* (Environment Agency, 1998)	EU
1998	Stream Visual Assessment Protocol. Washington, DC. / NRCS, 1998.	USA
1998	National Water Quality Assessment (NAWQA) Program - Revised methods for characterising stream habitat / USA (Fitzpatrick et al. 1998) http://water.usgs.gov/nawqa/about.html)	USA
1999	River Styles - *geomorphic condition approach* / Australia (Brierley, 1999; Brierley & Fryirs, 2005)	AUZ/NZ
1999	Riverine Habitat Audit Procedure / Australia (Anderson, 1999)	AUZ/NZ
1999	Index of Stream Condition (ISC) / Australia (Ladson et al. 1999)	AUZ/NZ
1999	Mean Trophic Rank - macrophytes / *phytoplankton indices* (Holmes et al. 1999)	EU
1999	Watershed habitat evaluation and biotic integrity protocol (WHEBIP) (Goforth, 1999)	USA
2000	AUSRIVAS (*derivative of British RIVPACS*)/ Australia (Simpson & Norris, 2000)	AUZ/NZ
2000	Habitat Predictive Modelling / Australia (Davies et al. 2000; Parsons et al. 2004)	AUZ/NZ
2000	Australia & New Zealand Environment and Conservation Council (ANZECC) Water Quality Guidelines (ANZECC, 2000)	AUZ/NZ
2000	EU Water Framework Directive - Good ecological status (GES) / potential (GEP) (EC, 2000)	EU

2000	Water Quality Criteria Survey / Norway (Bratli, 2000)	EU
2000	Stream habitat assessment method / King County, USA (Fevold et al., 2000)	USA
2001	Urban River Survey / UK (Davenport etal, 2001)	EU
2001	Stream corridor Assessment Survey / Maryland, USA (Yetman, 2001; 2002)	USA
2002	Pressure-Biota-Habitat (PBH) / Australia (Chessman, 2002)	AUZ/NZ
2002	Stream Health Monitoring and Assesment Kit / NZ (Biggs et al. 2002)	AUZ/NZ
2003	Hydromorphological survey / Germany (CEN, 2003)	EU
2004	Vermont Stream Geomorphic Assessment - Phase 2 Rapid Stream Assessment / USA (Vermont Agency of Natural Resources, 2004)	USA
2004	WDWF Stream habitat restoration guidelines: Stream Habitat Restoration Guidelines (SHRG) Ch3 Stream habitat assessment / Washington, USA (Saldi-Caromile et al. 2004)	USA
2004	USEPA Wadeable Streams Assessment (USEPA, 2004)	USA
2007	Theoretical framework of the urban river restoration planning (Zhao et al. 2007)	ASIA
2008	Vermont Rapid Habitat Assessment (RHA) / USA (VANR, 2008)	USA
2009	Integrative Fuzzy Hierarchical Model / China (Zhao & Yang, 2009)	ASIA
2010	Urban Stream Morphology (USM) Index System (Xia, et al. 2010)	ASIA

The following overview of assessment methodologies provides a representative sample of the main approaches used in river management practice on rivers worldwide (whilst acknowledging that some methods may not be available via the internet). This section is intended to provide a broad comparison between different international approaches, to review the international context for development of interdisciplinary river assessment methods, and includes references to urban rivers where relevant. A more detailed consideration of urban river habitat assessment is provided in section 2.2.5.

Following closely behind developments in river classification (section 2.2.2), pre-1990s habitat assessment methods, emerging from the USA and EU, largely represent single focus perspectives based on deviations from reference conditions. Early assessment priorities, as determined by objectives (e.g. water quality, fisheries), appear focused on the links between aquatic species and in-channel physical variables, (e.g. Instream Flow Incremental Method (IFIM)/PHABSIM, Bovee, 1978; BMWP, 1978).

Detailed geomorphological assessment of the physical structure of habitat features (e.g Habitat Quality Index, Binns and Eiserman, 1979; Pool Quality Index, Platts et al. 1983) also typically relate stream habitat to single or groups of organisms reflecting disciplinary research origins. While some acknowledgement of river processes is indicated early on, e.g. as eroding or depositional zones within the BMWP (1978), a dramatic increase in the publication of integrated assessment approaches during the 1990s indicates a progressive shift towards the application of broader scale associations between habitat and species conservation (Harper et al. 1992; 1995).

As international knowledge of river processes expanded, the use of multi-variable and multi-scale hierarchical approaches to river habitat assessment has increased on all continents. The timeline in Figure 2.1 indicates the frequency of assessment methods introduced during the 1990s and continental distribution of contributions as the pre-1990s dominance by the US and EU, is offset by new and innovative approaches emerging from Africa, Australia/New Zealand and Asia.

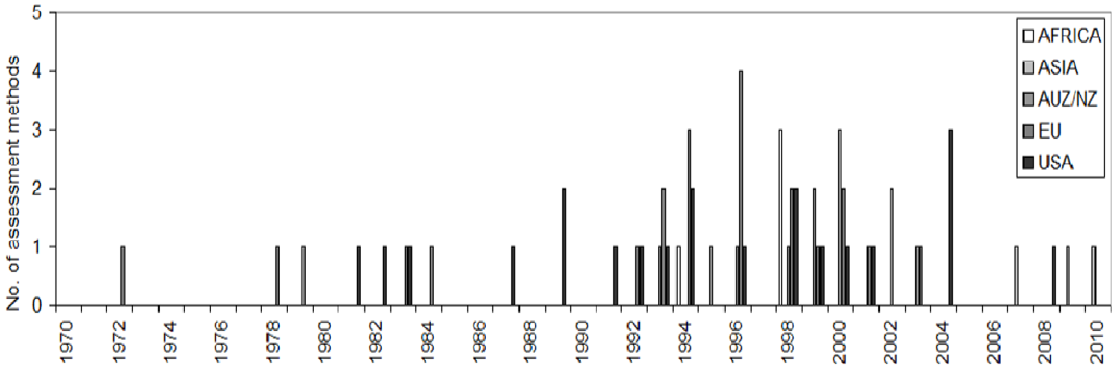


Figure 2.1 Timeline illustrating counts of river assessment methods reviewed, sorted by continent and year of publication

Integrated assessment approaches emerging in the 1990s included new methods from Australia (e.g. State of the Rivers Survey, Anderson, 1993; Geomorphic River Styles, Brierley et al. 2002) and Africa (e.g. South African Scoring System, Chutter, 1994; Integrated Habitat Assessment System, McMillan, 1998) as well as the EU (River Habitat Survey, Raven et al. 1997; Stream Reconnaissance Survey, Thorne, 1998) and USA (Rapid Stream Assessment Technique, Galli, 1992).

Many of the European river assessment methods and drivers have already been discussed in relation to the development of concepts and classifications, and the significance of the WFD to ecological assessment approaches. The development of the Urban River Survey (URS, Davenport et al. 2001) provides an early example of an integrated anthropo-environmental method which combines measures of engineering impacts with bio-physical habitat to enable the relationship between impacts and responses to be characterised and assessed.

In the US, an influential presidential address in 1997 to the North American Benthological Society (Stanford, 1997; Palmer, 1999) shifted the focus of state environmental protection agencies from ‘pollutant source’ based approaches to ‘more holistic watershed based strategies’. While each state is required to develop water protection programmes and methodologies (CWA and US Senate, 2002), additional support is provided through federal guidance (e.g. Rapid Bioassessment Protocols, Barbour et al. 1999; Wadeable Streams Assessments, USEPA, 2004)**.** While a great many integrated river assessment methods originate in the USA, examples specific to urban rivers or streams were not discovered, although the literature provides many examples of the application of stream habitat assessment methodologies in urban catchments (Booth, 2005; Meyer et al. 2005; Bressler et al. 2008).

The development of integrated river assessments specific to Australia and New Zealand have contributed many methods since the mid-1990s (e.g. Geomorphic River Styles, Brierley, 1996 and Brierley et al., 2002; Riverine Habitat Audit Procedure, Anderson, 1999; Pressure-Biota-Habitat (PBH), Chessman, 2002) and the first national survey of Australian river health undertaken in 2000 using the Australian Rivers Assessment bio-physical methodology (AusRivAs, Simpson and Norris, 2000). A specific method for urban rivers and streams, the Urban Stream Habitat Assessment (USHA, Suren, et al. 1998) is based upon a combination of physical habitat and biological (invertebrate) data, scored independently and integrated through the USHA method.

Emerging methods from Asia include the innovative development of ‘fuzzy’ logic approaches (e.g. Integrative Fuzzy Hierarchical Model, Zhao and Yang, 2009) whereby individual environmental indices (hydrological regime, water and sediment quality, aquatic life, riparian zone and physical structure) are weighted hierarchically and combined through a 3 stage decision making process to evaluate river quality. Weighting values, decided by expert judgement and public participation, can be modified according to the individual needs of assessment projects, thus allowing flexibility to fit purpose. The weighted indices are then used to categorise the river using 5 grades ranging from ‘Sick’ to ‘Very healthy’. A ‘single factor’ judgement matrix is then used to create a final composite assessment of the target river (Zhao and Yang 2009).

2.2.4 Urban rivers: assessment approaches and opportunities

'Successful stream rehabilitation requires a shift from narrow analysis and management to integrated understanding of the links between human actions and changing river health' (Booth et al. 2004 p.1351)

As well as the underlying natural environmental variables of urban catchments, specific challenges associated with urban river assessment relate to the type, history and extent of physical modifications to the river channel and surrounding catchment. The combined effects of the impacts imposed upon urban streams have been described as the Urban Stream Syndrome (USS) (Meyer, et al. 2005; Walsh et al. 2005). Physical changes resulting from land development and channel engineering which provide a wide range of river ecosystem services (e.g. abstraction, surface water drainage) also result in: decreased land surface permeability, reinforcement of river banks and bed, disconnection from riparian and floodplain habitats and water storage. Such physical changes affect both in-stream flow dynamics plus sediment inputs and transport through modified systems (Davenport et al. 2004; Findlay and Taylor, 2006). The presence of weirs and other impounding structures also contributes to habitat deterioration by increasing siltation of upstream reaches and creating physical barriers preventing fish passage and fragmenting river profiles into reach 'units' (Clifford, 2007). Further water quality issues due to polluted runoff, sewage misconnections, storm water overflows and urban trash inputs are closely linked to the inability of physically modified rivers to self-regulate efficiently through self purifying bio-physical processes e.g. via the saprobic system or oxygenation (Vagnetti et al. 2003).

2.2.4.1 Urban river assessment

The review of river assessment methods (in section 2.2.3) confirms that few are designed or adapted specifically for urban rivers i.e. equipped to integrate natural and artificial (anthropogenic) environmental or socio-environmental inputs at comparative scales. In urban river assessment, two important trends are emerging, the first focuses upon the production of integrated bio-physical assessment outputs, made accessible to local stakeholders and river managers by translating knowledge through socio-environmental objectives and integrating people into the planning and decision-making processes around river restoration and management (Boulton, 1999; Palmer et al. 2005).

The second approach takes integration a step further by incorporating measures of anthropogenic impact and socio-economics alongside environmental variables into (anthropo-environmental) assessment methodologies thus integrating human and bio-physical influences and responses within the ‘societal watershed’ of urban catchments (Meyer, 1997). To achieve this aim, explicit indicators of urbanisation such as percentage imperviousness or human population density (Meyer 2005); percentage utilisation rate of water resources or level of flood protection (Zhao and Yang, 2009) are integrated into new assessment methodologies currently under development. Included in this group is the Urban River Survey (URS, Davenport et al. 2001; 2004; Boitsidis et al. 2006; Gurnell et al. 2011), which specifically assesses the relationships between urban river habitat and channel engineering (as cross profile, planform and reinforcement level). A summary of the main components of the integrative urban river assessment methods identified in the literature is provided in Table 2.4.

River assessment is therefore not only an environmental management tool but also a socio-ecological and political device. In urbanised catchments, pre-restoration river assessments record changes in the condition of bio-physical aquatic environments, corresponding to human activities to derive environmental benefits as ‘goods and services’ from dynamic river systems (e.g. through water abstraction, (un)controlled discharges or floodwater conveyance). The indicators chosen to measure post-restoration changes are typically linked to environmental objectives specifically driven by political or social concerns, e.g. habitat attributes (biodiversity, fisheries).

More recently, the importance of ecological objectives acknowledges the integrated nature of aquatic ecosystems and mutual human-biotic dependency upon the supporting elements of water quality, quantity and physical habitats. Restoring the condition of these interrelated and dynamic attributes together therefore contributes to the overall wellbeing of river systems and human populations (Brierley and Fryirs, 2008).

2.2.4.2 Urban river opportunities

While urban river restoration offers opportunities to maintain the ecosystem services that catchment populations depend upon, it is not entirely risk-free as successful restoration of dynamic ecological functioning can not be guaranteed nor are outcomes predictable under infrequent but extreme environmental conditions. Recognition that restoration must be underpinned by sound scientific principles founded upon understandings of the bio-physical interactions of river systems, has generated multiple

Table 2.4 Urban river assessment methods

Method	**Type**	**Components**
Ecological Framework for Urban River Greenways (Baschak & Brown, 1995)	Framework	Riparian zone: vegetation, structure, connectivity, landscape elements. Visual design outputs
Urban Stream Habitat Assessment (USHA, Suren et al. 1998)	Bio-physical	Physical channel and riparian: habitat features (heterogeneity); channel and bank modifications (stability, roughness); vegetation structure; flow; substrate; landscape Final assessment is combination of two scores: USHA + Urban Community Index (UCI) score for aquatic invertebrates
Urban River Survey (URS, Davenport et al. 2001; 2004; Environment Agency et al. 2003; Boitsidis et al. 2006, Gurnell et al. 2007)	Bio-physical	Physical channel and riparian: habitat features; vegetation structure; bed and bank materials/modification; pollution indicators; nuisance species; land use. Classification and PCA multivariate gradient analysis outputs
Physical Habitat Assessment Score (PHAS, Booker et al. 2003)	Bio-physical	Based upon PHABSIM model, applied to reaches with engineering / management changes; specifically relates to fish habitat requirements. Score rating output.
Urban Catchments Stressor Gradients: (1) Urban Gradients (Bressler, et al. 2008) (2) Biological Potential (Paul et al. 2009)	Bio-physical / Social	(1) Biochemical, physical habitat & hydrological data vs Land Use/Land Cover (LULC), population & road density (Urban Index). (2) Biochemcial, physical habitat and land use data vs Urban Index Multiple regressions used to determine & validate multi-metric indices gradients.
Urban Stream Morphology (USM) Index System (Xia, et al. 2009)	Bio-physical / Social (urban function)	Physical channel and riparian: habitat features; vegetation structure; bed and bank materials/modification; land use; aesthetics; access to water; public satisfaction. Mathematical model score outputs for habitat; security & landscape.
QUERCUS Toolkit. (LB Lewisham, 2009).	Framework	Standard habitat assessment methods (RHS, RCS) combined with community consultation. Stop/Go mechanism questionnaire – simple socio-environmental decision making tool for planners. Evaluation report output

calls for a focus on reinstating *fluvial processes* and *ecosystem functioning* rather than aiming to recreate particular channel forms (Newson, 2002; Ward, et al. 2001; Gurnell et al. 2000; Vaughan, et al. 2009). Importantly, the EC Habitats Directive (92/43/EEC) and WFD each recognize that the overall wellbeing of aquatic habitats and river systems relies on the maintenance of ecological function. This understanding now underpins many of the restoration efforts undertaken by the EA in the UK.

The importance of taking an urban ecological perspective in understanding the rehabilitation potential of urban rivers is emphasised within the literature (Alberti, 2008); however the inclusion of social, economic and cultural or behavioural assessments of human populations in urban river assessment and restoration planning is also highlighted as essential by several authors (Pickett et al. 2001, Findlay and Taylor, 2006; Walsh et al. 2005; Meyer et al. 2005; Baschak and Brown, 1995).

2.2.4.3 Urban river restoration and interdisciplinary perspectives

Urban river restoration and associated post-project management, presents an important focal point for the conjunction of vital human and physical geographical components (Figure 2.2). The policy drivers for urban river and floodplain regeneration are both environmental (e.g. WFD, 2000/60/EC; Habitats Directive, 92/43/EEC; Making space for water: Defra, 2005) and social (e.g. planning guidelines PPS1, Local Agenda 21). The practical implications for the functioning of multi-disciplinary restoration teams have been reported and reviewed in the literature from both environmental (Newson and

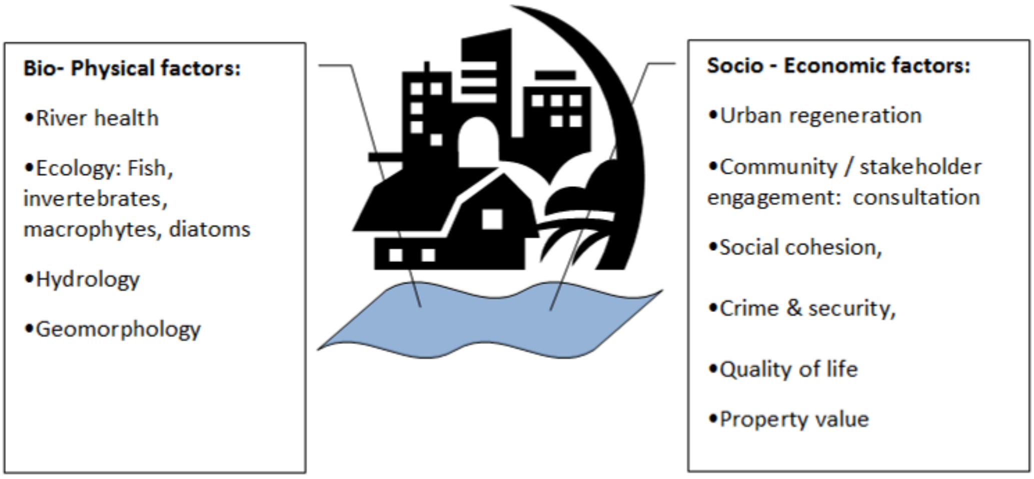


Figure 2.2 Components of urban river restoration identified within the literature

Large, 2006) and social (Eden et al. 2000, Eden and Tunstall, 2006) disciplinary perspectives.

The environmental case for urban river restoration is clear, with awareness of the need to rehabilitate damaged aquatic systems supported by a post-1980s groundswell of legislative and political support for ecosystems approaches and 'new' integrated bio-physical assessment methodologies crossing previously distinct boundaries. From the social perspective, the incorporation of ecological elements into urban regeneration agendas also became a reality in the mid-1990s.

Although recognised as valuable, implementing urban river restoration in the UK has been piecemeal, with case-specific delivery approaches through partnerships, led historically by the EA but increasingly by local authorities with support from public and private sector river-science experts. Researchers investigating the socio-environmental outcomes of integrated urban river restoration projects which aimed to regenerate urban 'blue' places as safe and cohesive 'liveable landscapes', found that in reality projects often fell short of aspirations, at worst representing 'safe, apolitical' regeneration opportunities promoting social goals but delivering little in practice (Eden and Tunstall, 2006). Eden, et al. (2000) highlight the need to integrate human-nature elements in recognition of the transformations of 'nature-culture' and actor-network relationships through urban river restoration projects, but also realise that philosophical interpretations of nature-society disconnections are less useful for practical environmental management. The opportunity for human-nature transformational experiences through urban river restoration, is however an important component, and closely associated with the active support and involvement by local communities to underpin long term sustainable management strategies. Analyses of these interactions are less prominent within the river-science literature, but are recognised by Campbell, (2005) through her experience of interdisciplinary conservation biology research

The decision making involved in urban river restoration must therefore account for both environmental and social actions and consequences. A clear message emerges for the need to develop more integrative processes to strengthen the 'nature-culture', socio-environmental and socio-economic linkages around urban river restoration projects to support long-term sustainable outcomes. For environmental and social scientists alike, integrating concepts and components of unfamiliar disciplinary traditions presents philosophical obstacles requiring new forms of conceptualisation and language as well as traditional empirical or qualitative approaches (Campbell, 2005). While new integrated anthropo-environmental assessments are beginning to inform international urban river restoration schemes, the need for more socio-environmental and socio-economic assessment is recognised (England, 2009, pers. comm.) however, a relative shortage of appropriate assessment and monitoring tools remains.

2.2.4.4 Urban River Restoration integrated appraisals: examples of socio-environmental assessment

Eden and Tunstall (2006) identified domination of the urban river restoration literature and practice by scientific and technical aspects and found public involvement and social and political challenges (e.g. knowledge deficits) following old models of subordination, and experimental technocratic top-down approaches out of balance with the social aspects of river restoration. Their recommendations included more effective, early-stage public participation processes to overcome ‘knowledge deficits’; expectation management; and information exchange, in order to integrate the social and environmental science and set explicit and measureable social objectives based on public views and participation from the outset and facilitate post project evaluation. Despite the shortage of ‘ready-made’ socio-environmental assessment techniques, the aspirations of environmental managers to achieve more holistic outcomes and some notable examples of integrated urban river restoration and appraisals, are providing valuable evidence of successful outcomes and indicators of future development possibilities (e.g. QUERCUS Toolkit, LB Lewisham, 2009).

Examples of urban river restoration projects where social factors were a core objective include the 1994 river Skerne restoration, delivered through an EU-Life project that supported collaboration between the UK and Denmark to restore the semi-urban Skerne in County Durham, plus two other rural rivers (R. Cole: UK and R. Brede: Denmark). The Skerne project’s primary objectives were to demonstrate urban river restoration benefits for Integrated Catchment Management and covered multiple socio-ecological objectives (e.g. water quality, flood prevention, nature conservation and amenity) thus illustrating ‘*how to put partnerships together to facilitate achievement of common goals that cannot be achieved by single agencies alone*’ (Holmes and Neilsen, 1998 p. 186). Lead project management, undertaken by Denmark, followed a structural and procedural model used on previous Danish river restorations, and included the appointment of a full-time locally based Community Liaison Officer. This role was central to the consultation strategy: to build and maintain links with local stakeholders (individuals, schools, special interest groups); to maintain contact and communications via regularly updated progress bulletins and on-site information boards. Key lessons learned from the project are highlighted by Vivash et al. (1998 p. 205) and summarised in Box 2.3.

The 2004 Brent River Park Restoration Project (BRPRP) in North London, also featured early-stage community consultations. Eden and Tunstall (2006) provide an account of the project from its identification as a potential restoration site, through catchment planning processes (Environment Agency, 1997) to the planning stages and conclude with a summary of key lessons (Box 2.3). The BRPRP socio-environmental objectives (water quality; habitat and wildlife management; site access for diverse neighbouring communities; strategic links to the London Cycle Network; reuse of existing buildings; community safety; and vocational training for unemployed youth) fitted closely with the local authority's (Brent Council) commitment to sustainable urban regeneration and Local Agenda 21. While community involvement in the initial consultation phase and environmental decision-making began in 1999, well before on-site works commenced in 2002, initial community engagement efforts employed 'top down' style approaches rather than the inclusive and visually engaging 'Planning for Real' community planning model (www.planningforreal.org/) often used to scope urban regeneration options.

The EU Life sponsored QUERCUS (Quality Urban Environments in River Corridors Users and Stakeholders) provides a recent example of integrated urban river restoration on the Ravensbourne in Southeast London (LB Lewisham, 2009) including further recommendations identified through post project appraisals (Box 2.3). Information on the interdisciplinary planning and managing approaches applied during the rivers Brent and Ravensbourne restorations are described through the Case Study investigations reported in chapters 5 and 6.

2.2.5 Urban River assessment: challenges and choices

Any river assessment may present a number of challenges, whether gathering data for research purposes or to meet management objectives, starting with the selection the most appropriate indicators, techniques or scale of observations, to the synthesis and reduction of data and communication of results. A clear definition of purpose at the outset is therefore essential to the development of objective-focused cost-effective assessment and monitoring strategies. In the UK, WFD requirements to achieve good

Box 2.3 Lessons learned from river restoration projects

River Skerne Restoration: Lessons learned via consultation process (Vivash et al. 1998)

1. Consultation commenced at the very beginning of the project when aims and objectives were explained;
2. Precise descriptions of proposals, and their consequences, were set out as the design developed, often at an individual level;
3. Time was allowed to keep people informed of progress, and to win their confidence and trust;
4. Consultation was meaningful; detailed proposals were seen to be influenced by consultees;
5. Equal consideration was given to all interests

Brent River Park Restoration Project – Post- project appraisal (Eden & Tunstall, 2006)

1. Consider river restoration projects as both environmental and social meriting the integration of science and social science.
2. Set explicit and testable social and scientific objectives simultaneously: to measure success; promote better evaluation of projects and reinforce integration of the science and social science from the outset; include objectives based on public views.
3. Design and implement an early, continuing, and effective public participation process involving more innovative methods to emphasise practical involvement; engage people in understanding the scientific objectives and constraints on river restoration; identify local people's aspirations and priorities for a river site and incorporate them into the design; and to foster greater public ownership of and pride in local environmental activities.
4. Ensure the adequate funding and development of public involvement and participation as an integral part of the programme of works and not as an afterthought, e.g. with a local community liaison officer throughout the process (as for the R. Skerne)
5. Design and fund monitoring, evaluation, and publication of results as an integral part of projects and integrate social scientific and scientific input throughout.

QUERCUS in Lewisham Evaluation Report: Section 5 - Lessons Learned (LB Lewisham, 2009)

1. Expect controversy;
2. Do everything possible to communicate transparently and openly with local people and community groups at the earliest possible opportunity, drawing particular attention to any potentially controversial issues;
3. Allow opposition to challenge ideas and bring about design adaptation, but not to dilute central themes and outcomes (e.g. local opposition resulted in fewer trees being felled and more new trees planted without compromising the design objective of clear sight lines and a welcoming park entrance)
4. Concentrate capital funds for use in a small area rather than spreading them thinly to create clear positive outcomes which can attract further funding
5. Build the success of the project not only on the transformation of the river corridor, but also, importantly on the engagement of local people.
6. Enable people to be involved and to experience the riverine landscape at the level to which they are interested and able by offering a combination of frequent volunteering opportunities as well as annual clean up events or fun days
7. Allow people to value the park more as a contributor, rather than casual visitor.
8. Encourage investment by the community as a key part of transforming their public spaces.

ecological status or potential and public involvement (EC, 2000) demands clear indicators of positive integrated environmental outcomes and sustainable (i.e. socio-environmental-economic) management approaches.

While the review of international river assessment (section 2.2.3) reveals several integrated approaches, by comparison, the development of methods specifically for urban rivers appears limited. However, applying standard assessment methods to urban rivers and streams becomes problematic, especially when recorded observations are so far removed from reference conditions that results provide minimal information for heavily impacted reaches (England, 2010 pers. comm.). In management terms, standard river habitat assessments with low sensitivity to physical modifications therefore have limited value in distinguishing between urban river reaches or identifying varying potentials for remediation.

This section considers some important challenges relating to river bio-physical assessment highlighted by the literature and their significance for urban rivers. These practical issues (summarised in Table 2.5) relate to identifying suitable approaches that can effectively (i) assess dynamic processes; (ii) provide scale appropriate outputs; (iii) allow the integration of different data types; (iv) enable standardisation and replicability of survey methods; (v) communicate results to stakeholders.

Table 2.5 Summary of key physical river assessment issues identified within literature

Issue	**Description**
Assessing dynamism	Identifying suitable rapid assessment or reconnaissance indicators of dynamic processes as measures of healthy river function;
Scale appropriate assessment	Selecting the cost-effective method(s) of assessment at an appropriate scale for management purposes i.e. objectives, and for longer term monitoring strategies;
Standardising data	Standardising field survey protocols and ensuring that data collection is replicable;
Integrating assessment data	Integrating multiple types of river assessment data gathered at different temporal and spatial scales;
Communicating results	Communicating results to stakeholders and across disciplinary boundaries.

2.2.5.1 Assessing dynamism

Despite the importance of dynamism to healthy river function, (Emery et al. 2003; Gurnell et al. 2004; Latterell, et al. 2006), the literature exposes a shortage of methods specifically designed to examine such processes. River assessment methodologies associated with individual river-science disciplines (e.g. geomorphology, biology, bio-chemistry) each examine discrete aspects of river functioning and may provide either ‘snapshot’ (e.g. water quality data) or interactive process related (e.g. bio-physical habitat conditions for fish spawning etc) evaluations as a basis for assessing river condition. Multi-focus, river habitat assessment methodologies may provide broader information on river functioning at the reach scale by recording the diversity and extent of bio-physical habitat features or ‘patches’, indicating in-channel processes such as energy transfers e.g. sediment exchanges (e.g. Latterel et al. 2006) and ecological function e.g. habitat patches (Pringle et al. 1988; Ward et al. 1999, 2001).

Stream energy functions, which distribute and structure sediments and organic inputs thus creating habitat heterogeneity, not only support aquatic species’ resilience, but also the biochemical regulation of water quality within the river systems (Vagnetti et al. 2003). As such, they represent essential components of a healthy functioning river system. Hydrological science not only encompasses a wide range of spatial and temporal dimensions, but also provides a link between geomorphology and river ecology. As dynamic flow regimes shape the structure of the river channel, riparian corridor and the habitats of the aquatic biota, these in turn have a feedback effect on the hydrology and hydraulics of the river system at a range of scales (Gurnell et al. 2000).

Given the importance of physical heterogeneity and dynamism to healthy river functioning (Ward et al. 1999), the assessment of physically modified rivers demands information on process-related forms in the context of the engineering history. The localised nature of engineering impacts along river systems itself introduces another (artificial) variable to urban catchments. The opportunity to assess rivers in relation to channel engineering is provided by the Urban River Survey (Davenport et al. 2001), which enables assessment of river habitat characteristics in relation to local channel modifications. As Walsh et al. (2005) note, the variability of outcomes to similar impacts in different locations, plus the likelihood of stressors combining in different ways demands urban river assessment methods with the capacity to distinguish and interpret a range of potential responses, some of which may have causes remote to the observed effects.

2.2.5.2 Selecting assessment approaches

For long-term integrated catchment management, the choice of assessment method is an important part of planning and budgeting (Brierley et al. 2002). Different approaches to river assessment include measures of river condition (based on bio-physical or ecological parameters), or river health (including socio-economic parameters) (Table 2.6). Depending upon objectives, assessment may be periodic (i.e. temporal or spatial) for comparative purposes, in which case appropriate scales need to be selected to ensure compatibility with future or historic surveys. Gathering data through detailed baseline study assessments generally forms an integral part of river restoration project design, but longer term assessment and appraisal is often neglected or inconsistent (Downs and Kondolf, 2002, Bruce-Burgess, 2004).

Table 2.6 Approaches to river and fluvial process assessment (adapted from Brierley and Fryirs, 2008)

Approach	**Characteristic**
River condition	(i) Audit – static (ii) Assessment of ecological integrity – i.e. **dynamic function & processes** – pressure & response indicators; temporal factors (history etc) etc
River health	(i) Including socio-economic landscape – essential feature for river management and decision making purposes (ii) As part of planning process for habitat management (BAP) targets

Assessment choices and frequency of survey for restoration projects will be guided by project objectives (England et al. 2008) and the characteristics of subject reaches and wider catchment.

The diversity of assessment options available has led to the development of new monitoring guidance for river practitioners in the UK. Designed to provide a framework for assessing long-term post-restoration monitoring strategies, the Pragmatic River Assessment Guidelines for Monitoring Options (PRAGMO, RRC 2011) uses a matrix approach to facilitate assessment method selection for post-project monitoring strategies that combines the scale of restoration works with the certainty of restoration technique outcomes (England, et al. 2008; Mant and Eyquem, 2009). As such PRAGMO aims to simplify and update the JNCC common standards monitoring guidance for rivers (www.jncc.gov.uk/).

2.2.5.3 Standardising data

The importance of standardised in-field assessment methodologies presents a challenge due to the inherent variability of river environments and modifications. The repeatability of surveys is fundamental in ensuring the reliability of baseline data for objective setting, appraisals and adaptive management. Particular issues regarding the reliability of field data collection raised by Maddock (1999), include environmental variability, data relevance and objectivity. Firstly, regional hydro-geological variability may influence the preferences of aquatic biota populations, whereas relevance reflects the risks of short term visions and limited surveying. The latter depends upon the accurate and consistent recording of key features (e.g. riffle counts, vegetation cover percentages) susceptible to regional and subjective variability (Szoszkiewicz et al. 2006).

Subjectivity is acknowledged as an inevitable aspect of rapid assessment protocols (Mant and Eyquem, 2009; Maddock, 1999). For example, the EA River Habitat Survey (RHS) training allows for small margins of error within feature counts due to surveyors' perceptions of features. The practical reality of in-field assessment, which requires the evaluation of often complex and ambiguous features, with restricted access or visibility (especially within constrained urban environments) presents a risk of compromising data consistency and reliability. While these aspects may be accounted for within training programmes and decision making stages they present important issues for knowledge transfer and transparency.

2.2.5.4 Integrating assessment data

Since the late 1960s, an ecological systems approach has been used to draw upon multi-disciplinary knowledge bases and develop understanding of complex natural environment processes (Clarkson, 1970; Brierley, 2008). For example, Dollar et al. (2007) argue that an interdisciplinary framework involving ecology, hydrology and geomorphology is essential to understanding the multi-causal relationships that occur within rivers, thus building on Thoms and Parsons (2002) multi-scale eco-geomorphological framework (Figure 1.4).

As river assessment approaches become increasingly integrated, a growing body of literature highlights the need to develop strategies to combine survey data at different spatial-temporal scales (Minshall, 1988; Lorenz, et al. 1997; Maddock, 1999; Gurnell, et al. 2000; Dollar, et al. 2007). The detection of dynamism and diversity in impacted urban streams demands an enhanced sensitivity to identify and evaluate fluvial and geomorphic processes via habitat features at the meso- and micro-scale, which may be lost on the scale of standard river assessment methods; and to compare findings on a catchment scale. The importance of crossing disciplinary boundaries and developing integrated assessments of environmental (bio-physical) and social data at comparative scales is also emphasised by Petts (2008) to achieve sustainable ecological flow management.

The use of predictive models and multivariate analyses to investigate relationships between variables is at an experimental phase, with new integrative methodologies developing multi-metric approaches to river management which have the capacity to combine a wide range of indices to determine river condition (Boulton, 1999). To achieve this, multiple indicator approaches require ways to combine discrete inputs through aggregative, weighted or otherwise selective methodologies (Table 2.7).

Table 2.7 Methods of combining integrated assessment outputs

Method	**Example**
Aggregative indicators approach	Riparian, Channel And Environmental (RCE) Inventory (Petersen 1992); Index of Stream Condition (ISC, Ladson et al. 1999).
Weighted methods	Analytic hierarchical process (AHP); Urban Stream Habitat Assessment (USHA, Suren et al. 1998); integrated fuzzy hierarchical assessment model (Zhao and Yang, 2009)
Lowest common denominator	Water Framework Directive (WFD, EC, 2000)
Matrix selection method	River Restoration Potential Questionnaires: Summary and Decision Matrix (MS Excel format) (RRC, 2007)

Solutions vary and integrative assessment approaches identified within the literature, range from differential weightings, typically based on expert opinion, e.g. Integrative Fuzzy Hierarchical Model, (Zhao and Yang, 2009), to a determination of outcome by the poorest denominator, e.g. Water Framework Directive (WFD) ‘one out all out’ approach (Borja and Heinrich, 2005). Both methodologies form parts of broader frameworks that regard both ‘top-down’ and ‘bottom-up’ perspectives as essential to the success of river assessment and management. Other approaches amalgamate social and environmental data using more qualitative inductive methods e.g. the Ecosystem Services Assessment (MA, 2005a) or the RRC river restoration potential questionnaire (2007).

The advantage of combining only multi-disciplinary environmental science data comes from the shared methodological and analytical approaches and common language which provide continuity, facilitate communication between practitioners and application within adaptive management strategies (Newson and Large, 2006). By contrast the differences between the physical and human geographies are more conceptual, methodological and linguistic (Rogers, 2006; Holt and Webb, 2007). Further discussion of integration issues relating to the interdisciplinary planning and management of urban rivers continues in section 2.3.4.

2.2.5.5 Communicating results to stakeholders

The wide variety of river habitat assessment methods reviewed reveals an equally diverse array of technical and non-technical outputs, which vary in style and accessibility to non-river-science stakeholders. These range from academic research based mathematical models (e.g. Xia et al. 2009; Bressler et al. 2008) to river management tools (e.g. Booker et al. 2003; Suren et al. 1998) and local authority evaluation reporting (LB Lewisham, 2009; Woolley, 2009). While some highly technical modelling approaches require detailed interpretation and translation (e.g. PHABSIM, Maddock, 1999), others, orientated towards social objectives, are designed to deliver more qualitative outputs (Boulton, 1999; Karr, 1999).

For urban river management contexts, summary assessment outputs provide essential contributions to decision making and the evaluation of options for intervention or restoration works (e.g. site selection, baseline studies); and post-restoration outcomes (response monitoring strategies) to appraise the extent of river function restoration (Ward et al. 2001). Lessons learned through urban river restoration appraisals provided in section 2.2.4.4 reflect the ongoing challenges of integrated management of socio-environmental projects. Several of the themes raised are developed further in section 2.3.

2.2.6 Conclusions for Urban River Assessment

The historic review of emerging concepts in fluvial geomorphology, river ecology and their interface (Table 2.1) illustrates how understanding of the multi-dimensional nature of stream structure and function has established over time and extended to incorporate the human dimension. The literature illustrates how scientific knowledge of river bio-physical processes has evolved from discrete purpose-orientated disciplinary foci to ecological system based understandings and the development of integrated multi-variate assessment methodologies designed to support the rehabilitation and adaptive management of historically damaged rivers. Progression towards integrated river assessment and management approaches are paralleled by cross-disciplinary recognition of the need to restore dynamic processes and bio-physical diversity within aquatic systems: to build resilience against future environmental change; to redress the legacy of historic physical modifications; to reinstate ecological functioning and thereby maintain the services provided by rivers to society. Hierarchical frameworks within river systems and patch dynamics (Frissell et al. 1980; and Wu, 1995) facilitate spatial and temporal interpretations of interactive, dynamic and diverse systems to describe multi-dimensional ‘Pattern-process-scale’ relationships. Although they represent vital descriptors of natural system complexity, these bio-physical theories do not yet extend to encompass human factors.

The challenges of implementing integrated river management associated with the complexity of environmental systems and fragmented strategies are highlighted by Clark (2002). A proposed model which links long term sustainable and holistic perspectives with robust and pragmatic approaches to uncertainty with responsive adaptive management, underpinned by ‘fuzzy’ decision support offers a framework which recognises the contrasting value systems of scientists and non-scientists in relation to certainty of outcomes. Here, Clark (2002) argues for the need to include social criteria into environmental assessments for decision making to support adaptive management and meet different stakeholder priorities.

The ongoing development of scientific knowledge relating to anthropogenic influences and sociological responses to river systems features are increasing consideration of human ecology and nature-culture within river management approaches. Practical efforts to integrate the assessment of human-nature interactions in river assessment provide a new dimension to bio-physical methodologies and parallel new interpretations of ‘reconciliation’ ecology whereby healthy functioning ecological systems and human involvement in conservation and environmental management are regarded as fundamental components within urban environments (Rosenzweig, 2003, Miller, 2005, Francis et al. 2011). Limited evidence of the application of these new concepts and methodologies in sustainable river and catchment management strategies indicate a knowledge gap waiting to be filled.

Increasing use of health metaphors to describe the need for a holistic view of river management and remediation (Maddock, 1999; Meyer, 1997, Karr, 1999; Norris and Thoms, 1999; Boulton, 1999) represents a powerful device that can be readily interpreted by people. The anthropomorphism of environmental systems, successfully applied through the Gaia Theory in communicating knowledge of scientific planetary functions (Lovelock, 2000), facilitates the transfer of specialist information by presenting river systems as complex living organisms with ‘vital signs’.

Cross-disciplinary challenges arising in relation to the application of integrated approaches to river management and restoration works, are identified by social scientific authors as, (i) the domination of planning and management design by techno-scientific disciplines and (ii) the inadequate communication of environmental techno-scientific information to non-scientific stakeholders. Evidence for a lack of novel approaches to social engagement, reinforcement of ‘knowledge deficits’ and disempowerment for non-speakers of technical languages (Eden and Tunstall, 2006) are stimulating physical scientists (who are inevitably regarded as having ‘ownership’ of the quantitative data and analytical information) to devise more integrative assessment approaches and dedicated community relations roles, e.g. include the Skerne and Ravensbourne restorations (Holmes et al. 1998; Tunstall et al. 2000; LB Lewisham, 2009).

Further efforts to raise the profile of urban river restoration projects through accessible outputs designed for public and non-scientific communications, e.g. QUERCUS Toolkit and Evaluation report (LB Lewisham, 2009), and London Rivers Action Plan (Environment Agency, 2009), demonstrate commitments by the scientific community to build connectivity between science and society. The development of appropriate ‘translation services’ to communicate specialist knowledge between the disciplines and to non-scientists, clearly require continuation of interdisciplinary exchange between the environmental and social scientists to develop new philosophical groundings for future approaches to develop.

The particular challenges of delivering the WFD and measures to restore ecological condition in urban rivers also involve both ‘top down’ (River Basin Management Planning) and ‘bottom up’ (stakeholder engagement) approaches which require hierarchical scaling and translation between different disciplines and non-specialists. Further opportunities for socio-economic integration within river management through Ecosystem Services Assessment (ESA) are considered in relation to urban river restoration governance in section 2.4.4. In terms of assessment, a broader socio-economic focus on the services provided by urban rivers to society, allows new social and physical geographical interactions to be identified and contribute to assessments.

Although many relationships present evaluation challenges, these also provide ample grounds for future research efforts.

Throughout this section, the literature reviewed has provided many opportunities to consider the application of river-science knowledge in practical urban river planning and management contexts. The next section (2.3) takes this further by considering urban river planning and managing from the perspective of environmental governance to review the literature relating to the characteristics of partnership and challenges of delivering urban river restoration measures.

2.3 Environmental Governance: Planning and management of urban rivers

This investigation of the literature relating to the environmental governance of urban rivers first briefly introduces the historic background to river management in London before considering the significance of sustainability discourses to present governance contexts (section 2.3.1). This section highlights some important challenges for delivering sustainability agendas and urban river management in relation to London.

Next, a series of theoretical models identified within the literature surrounding multi-disciplinary partnership work and interdisciplinary approaches are reviewed and used to build a series of frameworks against which to evaluate the case study evidence. In preparation for the research analysis, the main areas of investigation are focused around theories regarding partnership: structure and life-cycle (section 2.3.2), integrated management (section 2.3.3) and complexity (section 2.3.4).

The final section (2.3.5) provides some conclusions for urban river environmental governance emerging from the literature review in relation to the planning and management of urban river restoration and areas of research need.

2.3.1 Environmental and urban river governance: Historic and modern contexts

‘Governance is by no means a settled notion’

(O’Riordan, 2004 p.240)

A spectrum of definitions for environmental governance is identified within the literature, many of which are closely linked to sustainability discourses (Delmas and

Young, 2009, O'Riordan, 2004, Scrase and Sheate, 2002, Bulkeley, 2005). Together they describe a new system of governing, whose key characteristics involve a shift away from the 'expert driven' decision making structures, where power is held within state institutions, towards more inclusive partnership models and networks in which, '*state actors are not necessarily the only or most significant participants'* Bulkeley (2005, p.877).

The views of political analysts upon governance are summarised by O'Riordan (2004 p.240) as *'a new process of governing, a form of adaptive learning through partnerships and networks, a nesting of institutional forms across various scales from global to local'*. For Young (2009, p.12) environmental governance represents a social function with a protective role '*to guide or steer societies toward collectively beneficial outcomes and away from outcomes that are collectively harmful'*. The scale of these '*emerging hybrid, problem-solving governance arrangements'* ranges from the creation of global institutions to manage 'global commons', to '*the emergence of transnational networks and new forms of civil society'* (Bulkeley, 2005 p.877). The arguments within this thesis focus upon local and regional scale environmental governance approaches in the context of trans-borough administration and management of urban river systems. To set the context for the modern governance scenarios identified within the research material, the next section briefly reviews the history of urban river management in Greater London.

2.3.1.1 Water and urban river management histories and London context

Current approaches to urban river management face a range of challenges associated with the historic succession of water related management paradigms or phases, each of which have delivered river engineering legacies and system responses (White, 1998; Downs and Gregory, 2004; Allan, 2005). Early industrial uses of the Thames tributary rivers began with milling enterprises leading to the construction of channels and weirs to power water wheels for a wide range of activities ranging from grinding corn for bread to gunpowder (Barton, 1962). During different phases of London's development, many local tributary streams and rivers including the Thames itself were treated as open sewers with latrines built directly over them. As a result, several were fully enclosed in culverts or diverted into the sewage system (e.g River Fleet), during the two phases of sewer construction: firstly in the 17th century in response to the plague, and later in the 19th century by Bazalgette in response to the cholera epidemic and 'The Great Stink' of

1858. Although latrines were permitted, disposing of rubbish in rivers was a punishable offence (Barton, 1962, Ackroyd, 2007).

While London’s rivers were being maltreated as waste disposal systems, much of the city’s historic drinking water was supplied by the numerous springs and wells that existed near to areas of habitation. ‘*Liberty to transport water to the City from the Tyburn*’ was granted by King Henry III in 1236, and several conduits transporting water to the City of London were constructed (Halliday, 2004). Inadequate water supplies in the 17th century resulted in the privately sponsored construction of the New River, which brought freshwater from Hertfordshire to a reservoir system in Islington, North London, supported by the New River Act of 1609. By the 18th century, water supplies were managed by a large number of competing water companies until poor management and an increasingly complicated supply network eventually led to the creation of the Metropolitan Water Authority in 1902, which bought out the remaining London water companies (Halliday, 2004). Public ownership of the water companies, with the regulation of the aquatic environment (including drinking water supply, sewerage, flood risk management, land drainage, aquatic ecology and fisheries) falling to the Regional Water Authorities, lasted until their privatisation in 1989 when the responsibility for river management transferred to the newly created National Rivers Authority, forerunner of the Environment Agency (EA) which formed in 1996.

2.3.1.2 Modern environmental governance issues

Global changes in approaches to water management dating from pre-industrial to present times, are described by Allan (2005) as a series of paradigms (summarised in Table 2.8), to illustrate the socio-economic and political characteristics of successive time periods and their influence upon water and therefore river management strategies. This succession begins with a shift from pre-modern ‘command and control’ type approaches, with modest levels of impact, towards more extensive urbanisation and industrial development with the advancing engineering capabilities of the early 20th century. By the late 1960s awareness of the negative environmental impacts of engineering for resource supply and flood risk management upon rivers had gained widespread recognition (White, 1998). Although early attempts at integrated water management began before 1950, the complexity of competing interests, ownership issues and the dynamic nature of water resources limited their success (Biswas, 2004).

Table 2.8 The five water management paradigms. (Adapted from Allan, 2005)

Dating from	**Paradigm**			**Characteristic**
Pre-1850s	1st	Pre-modern		Engineering controls impacting on a modest scale
1890s	2nd	Industrial Modernity		Modernity inspired by the Enlightenment, scientific pursuit of knowledge, capitalism and belief that Nature could be controlled
1980s	3rd	Green	Reflexive Modernity	Developing out of pre-80s green movements; accompanied by shift to awareness of uncertainty and globalised risk; developing participation and adaptive management approaches
1990s	4th	Economic		
2000s	5th	Political & Institutional environmentalism (‘new’ green politics)		

The three most recent (post-1980s) paradigms describe an increase in environmental awareness from the third (Green) phase, partially suppressed by the rising dominance of market forces during the fourth (Economic) paradigm, then progressing to a more integrated fifth (Political & Institutional) phase (Allan, 2005). During the fifth paradigm the emergence of the principles of Sustainable Development, has endorsed the integration of social, economic and environmental objectives within development strategies.

2.3.1.3 Sustainable development and urban river restoration

The integration of environmental with socio-economic issues within mainstream policy from the 1960s onwards reflects the rise in awareness of human impacts upon the natural environment and urbanised rivers (Wolman, 1967). Global sustainability discourses emerging in the 1970s paved the way towards the adoption by nation states of the principles of Sustainable Development (SD) set out in ‘Our Common Future’ by Bruntland (1987) and formalised through Agenda 21 of the Rio Declaration on Environment and Development (1992). International acceptance of environmental priorities was further reinforced by the Multilateral Environmental Agreements (MEAs), and Millennium Development Goals (MDGs) passed under the Millennium Declaration (United Nations, 2000).

The increasing prominence of integrated water and river basin management in the 1980s (Downs et al, 1991) coincided with a rising awareness of the importance of catchment scale and geomorphological processes (Brookes, 1995, Newson, 2002), In this context, a growing interest in river restoration, brought together a multi-disciplinary group of scientists (with expertise in conservation, engineering, geomorphology, biology and other disciplines) to form the River Restoration Project (RRP) in 1992, The original aim of the RRP (fore-runner of the current River Restoration Centre) was to educate and motivate organisations or individuals involved in river management to restore the environments and aesthetics of Britain’s post-industrial damaged rivers (Brookes and Shields, 1996).

With European funding the RRP were able to successfully establish two ‘state-of -the-art’ river restoration demonstration sites within England on the Rivers Skerne and Cole. The RRP objectives included understanding and measuring both the environmental and social effects of the restoration work, e.g. on conservation value, water quality, recreation and public perceptions. A further objective: to develop methods of establishing partnerships for collaborations between institutions with shared aims (Brookes and Shields, 1996), reflects the post-modernist shift towards participatory, multi-disciplinary partnership and adaptive management approaches.

New emerging styles of governance involving partnerships and networks, provided flexibility and were able to respond directly to calls within Agenda 21 to integrate environmental and development objectives and to ‘*establish processes to increase the exchange of information, experience and mutual technical assistance among local authorities*’ (United Nations, 1992). However, despite support for integration at the highest levels, tensions remain between the traditional enterprise-based development models (prioritising economic objectives) over those that prioritise the well being of the environment and its ability to sustain human populations (O’Riordan, 2004; Raco, 2005, Giddens, 1990). A reluctance to move away from neo-liberal models paved the way for the rise of ecosystem services and valuation-led policy development (Eftec, 2006).

The practical challenges of delivering sustainable river management highlighted by Clark (2002) are closely associated with the recognised need for a holistic approach and participatory decision making involving stakeholders who may be unfamiliar and uncomfortable with the inherent uncertainties associated with complex environmental systems. In this context, the benefits of adaptive management strategies include the responsiveness to changing outcomes. Furthermore, Clark (2002) acknowledges the application of ‘fuzzy’ logic in decision-making, whereby incomplete knowledge of and uncertainties within, not only the natural, but also socio-economic and political environments, are inevitably built into ‘clear but cautious’ approaches to river management.

2.3.1.4 Sustainability challenges: Implementing social, economic and environmental objectives through urban restoration

The sustainable development discourses reveal emerging questions, relating to the relationships between science and society as well as people and nature (Raco and Dixon, 2007, Holt and Webb, 2007, Folke et al. 2002). In their review of the links between knowledge exchange and action for sustainable development and practitioners with different perspectives and priorities, van Kerkoff and Lebel (2006) present several critiques of conventional information exchange models (e.g. trickle down, transfer and translate) and propose new approaches that account for cultural (social and institutional) interpretations. By recognising the tensions between knowledge ownership and interpretation, emphases are placed upon participation, integration, techniques of learning and negotiation to produce more collaborative and inclusive outcomes (van Kerkhoff and Lebel, 2006). A review of integration issues with relevance to urban river planning and management is developed further in section 2.3.3.

The practical implications of Agenda 21 in supporting local authorities’ delivery of environmental governance objectives are substantial, but the degree of positive impact for urban rivers is questionable. For example, where enterprise-focused urban regeneration frameworks are deeply entrenched, the introduction of sustainability objectives has in some cases introduced tensions due to competing interests, in others a hybridisation of ‘ecocentric-sustainability’ with ‘anthropocentric-neoliberal’ approaches as experimental new models are tested ‘on the ground’ at various scales through ongoing development projects (Raco, 2005). The prominence of waterside developments and use of water in ‘re-visioning’ cities suggests that these tensions may also exist for urban river restoration projects e.g. where private developers represent stakeholders or sponsors.

The conjunction of urban regeneration and environmental rehabilitation aspirations within shared public open spaces represents a key physical and conceptual boundary zone in planning terms, where both independent and interactive social, institutional and environmental interests may hold different visions of future possible outcomes (Gregory and Brierley, 2010). Contrasting interpretations and expectations of outcomes for stakeholders highlighted by Tapsell (1995) may confuse inclusive decision making processes. Gregory and Brierley (2010) emphasise the vital importance of developing common goals and vision statements for river restoration projects with local communities. The emergence of two distinct social and physical science discourse strands arguing the importance of integrated socio-environmental assessment for sustainable river restoration (section 2.3.3), reflects the significance of these issues for both disciplines. However, based on experience as a social scientist in the field of biological conservation, Campbell (2005) argues that further facilitation and translation is needed to synergise disciplinary perspectives and philosophies.

2.3.1.5 Management challenges for urban rivers in the context of London

Issues regarding changes in urbanised catchments associated with sedimentation and erosion (Wolman, 1967); nutrient and pollutant levels, and hydrology and highlighted as the ‘urban stream syndrome’ (Meyer et al. 2005; Walsh et al. 2005), plus positive and negative public perceptions of urban rivers (Tapsell, 1995) present a wide range of management issues for urban river managers. While several researchers consider the impacts of urbanisation upon unchannelised rivers, the extent of engineering undertaken on London rivers determines a set of priorities associated with the historic legacies of industrialisation, residential development and flood control. At a recent strategic conservation (Rivers and Streams Habitats Action Plan) meeting, the main issues for London rivers were summarised by the EA as: (habitat) fragmentation, improving hydromorphology, increasing floodplain connectivity, and naturalising banks (Source: Rivers and Streams Habitat Action Plan Minutes, 15th June 2011).

The bio-physical degradation of London’s urban rivers, in conjunction with the disparity of administrative (local authority) and environmental (river catchment) boundaries further complicates the picture for the management of heavily modified urban rivers. Given the extent of physical modification in urbanised rivers and focus of this research project on bio-physical urban river assessment, a set of management challenges for channelized rivers outlined by Downs and Gregory (2004) provides valuable signposts towards significant issues also affecting heavily engineered urban rivers (Table 2.9).

Parallels between the management challenges for channelized rivers and the London river issues suggests that these may provide a useful framework for evaluating the effectiveness of urban river restoration management practice and outcomes in the context of London. In order to investigate this, a set of integrated management challenges for London urban rivers is presented with the case study results in Chapter 7.

Table 2.9 Challenges for river channel management. (Adapted from Downs and Gregory, 2004, p.236)

Main challenge	**Management focus**
1. Manage rivers as 'fluvial hydrosystems', incorporating knowledge of past, present and future conditions *(Spatial & temporal connectivity)*	Actions may be determined by habitat requirements of charismatic flora/fauna Identify best indicators of overall river ecosystem 'health'
2. Integrate conservation actions with water resources and hazard management	One prospect is the role of restoring meanders and floodplains to act as flood retention.
3. Protect naturally functioning river systems	Preserve intact natural habitats
4. Re-manage degraded systems	Improve environmental conditions and undo the degradation legacy through restoration

2.3.2 Partnership approaches to Urban River Restoration

The multi-disciplinary partnerships that arise through the planning and delivery of urban river restoration projects are characteristic of the new approaches to environmental governance and sustainable development described in section 2.3.1. The description of partnership by O'Riordan (2004, p235) as '*an increasing range of quasi-formal governing arrangements'* that '*geographers and environmental scientists are still developing their skills and experiences in connecting to and helping to design'*, indicates the fluidity and uncertainties still inherent in the new styles of governance.

Urban rivers have the potential to represent both positive and negative focal points for river-scientists, conservationists, flood managers, anglers, other aquatic interest groups and the general public. This breadth of perspectives and interpretations of urban rivers encompasses a wide diversity of knowledge and interests, linked together by the dynamic physical form and function of typically heavily modified and impacted water courses. Partnerships brought together by urban river restoration projects may therefore include a wide range of environmental and social interests. As such, the plurality within governing partnerships necessitates effective communications, not only across disciplinary boundaries but also across different partners' institutional (or individual) interests. The following examination of partnership theory aims to shed light upon how partnership functions relate to complex socio-environmental projects such as urban river restoration.

2.3.2.1 Characteristics of partnership

The emergence of partnership as a new approach to city regeneration governance has been studied extensively resulting in the identification of several core processes. Mackintosh (1992) identifies partnerships as synergistic, transformative (developing new qualities and strengths) and a mechanism for enlarging budgets. Perceived by Bailey et al. (1995) as complex and dynamic organisations and difficult to research, partnerships are also characterised as:

> *'..action orientated, pragmatic, innovative and responsive to new opportunities, while maintaining few records of past achievements or having the time or resources to evaluate their activities fully.* (Bailey et al. 1995, p.3)

The latter point is particularly relevant to urban river restorations for which the shortages of post-project evaluation and appraisal data are reported as problematic (Downs and Kondolf, 2002).

Since the post-1997 introduction of new 'joined-up' thinking and 'urban renaissance' strategies of the incoming Labour government, partnership and multi-sector approaches to urban planning and development have increasingly become the norm (Bailey, 2005). In contrast to the model of formalised partnership, based upon more stable relationships between organisations with clearly defined boundaries, the occurrence of relatively informal networks is differentiated by Lowndes et al. (1997) and defined by the voluntary relationships between individuals that arise without clear boundaries or stability (Table 2.10).

Table 2.10 Features of Networks and Partnerships. (Source: Lowndes et al. 1997)

	Partnership	**Network**
Focus	Organisational relationships	Individual relationships
Motivation	Voluntaristic or imposed	Voluntaristic
Boundary	Clear	Indistinct
Composition	Stable	Fluid
Membership	Defined by formal agreement	Defined by self and/or others
Formalisation	High	Low

Alongside acknowledgement of the importance and value of specialist and disciplinary knowledge in shaping our understanding of the natural and social sciences, challenges for partnership working include the perpetuation of specialisms, which Bailey (2005) traces back to education frameworks and practitioner training pathways. Likewise, Scrase and Sheate (2002) argue that the dominant positivist and deterministic mindset amongst environmental professionals reflects background training in natural sciences and engineering. To counter this, Bailey (2005) also argues that the shortage of skills and experience in integrated multi-disciplinary practice might be addressed through higher education, knowledge transfer and experience of interdisciplinary work with existing professionals.

Multi-disciplinary partnership configurations offer structures for re-orientating decision making, traditionally seen as hierarchical; and research, previously focused mainly upon processes at different discrete levels. By redefining conventional approaches to river management (described by Everard (2011) as 'silo thinking') to meet sustainability agendas and broader objectives, Bulkely (2005 p. 876) argues that discussions and decision making actually occur '*between, across and among scales, and through hybrid governing arrangements which operate in network terms'*. This interpretation of new hybrid forms of environmental governance echoes observations by Raco et al. (2006) regarding the integration of roles and responsibilities within urban brownfield regeneration practice and research. These theoretical arguments are considered in relation to the observed characteristics of the multi-disciplinary partnerships and networks involved in the urban river restoration case studies and presented in Chapter 6.

2.3.2.2 Partnership timeframes

The complexities of partnership working are not only conceptual, spatial and structural, temporal issues manifested as 'time-space politics', but they highlight the significance of different relative timeframes within the governance of urban regeneration Raco et al. (2008). The identification of political, institutional or bureaucratic timeframes, plus non-institutional human and environmental time-cycles reveals fundamental differences between artificial 'constructed' and more 'ecological' drivers of events and activities which may clash as partnerships work to deliver socio-environmental objectives.

The synchronicity of partnership functioning and project stages forms the basis of the partnership life-cycle described by Lowndes and Skelcher (1998). Four key stages closely associated with evolving processes, partnership characteristics and dynamics are identified as: (i) Pre-partnership collaboration; (ii) Partnership creation and consolidation; (iii) Partnership programme delivery; and (iv) Partnership termination and succession. Each stage is characterized by changes in modes of governance and stakeholder relationships (Table 2.11).

Table 2.11 Partnership Life-cycle stages, governance and relationship characteristics. (Adapted from Lowndes and Skelcher, 1998)

Life cycle stage	**Mode of Governance**	**Stakeholder Relationships & processes**
Pre-partnership collaboration	Networking: individuals/ organisations	Informality; trust cooperation; willingness to collaborate; collective purpose; Differential resources: inner/outer networks; some actors marginalised
Partnership Creation and Consolidation	Hierarchies established; Formalisation of authority	Negotiation & contest over membership; disruptions as balance of power codified; Hierarchical structures; formalized procedures
Partnership Programme Delivery	Market mechanisms: contracts; Regulating: contractors; Networking: bids	Low cooperation and mistrust between providers and purchasers; Hierarchies defined through bids and allocations; informal agreements support complex bid negotiations; trust based relationships with some partners
Partnership Termination and Succession	Networking: individuals / organisations	Uncertainty as network stability threatened by termination; potential for new links; trust and informality; negotiation for strategic role of partnership in succession.

While the literature provides helpful insights into partnership and governance time factors, they avoid the vitally important temporal aspects of environmental governance regarding ecological timeframes and natural cycles. The biological and meteorological temporal cycles and scales that underpin key environmental processes represent a prime example of fundamental science knowledge and key factors for consideration within environmental planning and delivery. Further evidence and discussion of the significance of institutional, human and environmental time frames for the case studies are provided within the results in Chapters 6 and 7.

2.3.3 Integrated management of urban rivers and public open spaces

Building on the challenges for London urban river management identified in section 2.3.1.5, the complexity of nature-society relationships associated with urban river restoration projects in public open spaces demands a variety of integrative approaches at many levels, e.g. for both socio-environmental assessment and project governance.

A wealth of different emerging models has generated a diverse literature on integration, however Scrase and Sheate (2002) argue that these are generally focused upon the *value* of integrated assessment methods; are critical of the shortcomings of individual approaches; and fail to differentiate between different forms of integration. They highlight fourteen different forms of integration and the inconsistencies which may risk undermining environmental objectives and efforts to implement sustainable development, many of which have clear implications for urban river restoration projects (Table 2.12).

Overall Scrase and Sheate (2002) find that integration itself presents challenges and takes many forms, not all of which are entirely environmentally supportive. Their categorisation of integration approaches indicates that the '*least likely to be environmentally supportive*' category, includes 'integration of business concerns' thus highlighting the perceived risks of *'promoting the prevailing economically driven paradigm'*, and leading to a final call for a paradigm shift to greater recognition of underlying environmental imperatives in sustainable development (Scrase and Sheate, 2002 p. 291). Despite this critique, the identification of discrete meanings of integration again offers a useful opportunity to evaluate the case study observations against theoretical models of integration. Two particular integration challenges of relevance to urban river assessment and knowledge exchange are explored further.

2.3.3.1 Integrating and communicating environmental and river science knowledge

As section 2.2.1 demonstrates, single disciplinary approaches have provided a wealth of specialist knowledge along with specific critical perspectives and skill based activities, including specialised forms of communication (Vanderstraeten, 2010). While disciplinary specialism has rapidly advanced knowledge of fluvial systems, a review of interdisciplinary research by the British Ecological Society states simply that *'no single discipline will be sufficient to address the problems to which society is now demanding answers'* (Holt and Webb, 2007, p.4). Although the benefits of interdisciplinary and integrated approaches are acknowledged and supported by environmental geographers and research funding bodies (Nissani, 1997; Meagher, 2005, Demeritt, 2009a), significant challenges have also been identified by those working at the disciplinary boundaries or 'spaces between disciplines' (Evans and Marvin, 2006; Raco and Dixon,

Table 2.12 Different meanings of integration in environmental assessment and governance. (Adapted from Scrase and Sheate, 2002)

Meaning	**Main focus**	**Type of policy learning**	**Level of policy change**
A. Integrated information resources	Facts/ data	Technical Social	Settings
B. Integration of environmental concerns into governance	Environmental values	Conceptual Social Technical	Goals Delivery Settings
C. Vertically integrated planning and management	Tiers of governance	Social Technical	Delivery Goals
D. Integration across environmental media	Air, land and water	Technical Conceptual Social	Settings Delivery Goals
E. Integrated environmental management (regions)	Ecosystems	Conceptual Social	Goals Delivery Settings
F. Integrated environmental management (production)	Engineering systems	Technical	Settings Delivery
G. Integration of business concerns into governance	Capitalist values	Conceptual	Goals Delivery Settings
H. The environment, economy and society	Development values (Ecosystem Approach)	Conceptual Social	Delivery Settings
I. Integration across policy domains	Functions of governance	Technical Social	Settings Delivery
J. Integrated environmental-economic modelling	Computer models (Ecosystem Services evaluation)	Technical	Settings Delivery
K. Integration of stakeholders into governance	Participation	Social	Delivery Settings Goals
L. Integration among assessment tools	Methodologies / procedures	Technical	Settings Delivery
M. Integration of equity concerns into governance	Equity / socialist values (Environmental Justice)	Conceptual	Goals Delivery Settings
N. Integration of assessment into governance	Decision / policy context	Social Technical	Delivery Settings

2007; Petts et al. 2008). At these critical interfaces, the nature and quality of disciplinary interactions are found to vary widely, ranging from a conjunction of multiple but discrete disciplinary inputs (multi-disciplinarity); to a metamorphic fusion of disciplinary cultures that transcends boundaries and forges new concepts and solutions (trans-disciplinarity). Falling between these extremes, interdisciplinarity looks for ways to integrate contributing disciplinary methodologies to identify commonalities and identities through shared concerns within real world issues.

Alberti et al. (2003) argue that despite interpretation of socio-environmental phenomena by both environmental and social scientists and awareness of the need for integration, persistent reductionist disciplinary traditions prevent a full explanation of the interactions between humans and ecological processes in human dominated systems. In order to progress environmental governance and move beyond traditional disciplinary limitations, Pickett et al. (1999) argue that interdisciplinary approaches require flexibility and the 'suspension of critical evaluation' to allow new associations and unconstrained constructive impulses to generate novel ways of working.

Approaches that are able to identify elements of common interest, known as 'boundary objects', have found success in achieving common understanding between scientists and policy makers. For example, The Netherlands' 'Green River' project described by Van der Windt and Swart (2007) provides evidence of how the 'vagueness' and ambiguity of the 'ecological corridor' concept enabled a common point of focus to develop, upon which different stakeholders could attach their own meanings. However, problems arising with different interpretations of the 'robustness' of the science underpinning conceptual claims became particularly difficult for ecologists as the evidence did not adequately support claims for species preference or conservation value. Here the emerging tensions generated by different scientific expectations (summarised in Table 2.13) sum up the philosophical clashes between social and environmental sciences, and thus pinpoint the interface for building new transdisciplinary understanding.

Ongoing development of similarly ambiguous but scientific socio-environmental assessment methods includes the use of 'fuzzy logic' to blur the deterministic and prescriptive boundaries that can limit the development of common understandings required for interdisciplinarity. e.g. Sustainability Assessment by Fuzzy Evaluation (SAFE) Phillis and Andriantiatsaholiniaina (2001) and the sustainable river management framework underpinned by '*fuzzy decision support*' described by Clark (2002).

Table 2.13 Potential sources of tension arising between scientifically sound and socially robust science. (Source: Van der Windt and Swart, 2007)

Classic science norms	**Social science norms**
Universalism - requires context free interpretation	Relativism - stresses context dependency
Credibility derived from peer review by scientists within discipline	Accepts quality assessments from scientists in other fields & non-scientists
Soundness implies unambiguous concepts and theories	Robustness may lead to vagueness to enable different sorts of knowledge, values and interests to be bound together.

In contrast to all of the limiting factors cited above, Gandy (2008) recognises that by articulating interrelationships, different insights can be incorporated through scientific explanation to produce coherent and mutually intelligible outputs. Whilst differences in language and culture and the use of different sets of skills by different disciplines were found to be potentially inhibiting, for others they are seen as being enriching for communications and coordinated research, offering new ways to support integrated decision making and achieve sustainable solutions (Petts et al. 2008).

2.3.3.2 Interdisciplinary approaches to urban river planning and management

The ‘benefits and burdens’ of interdisciplinary approaches identified by Pickett et al. (1999) caution against the premature use of traditional critical approaches stifling the progress of interdisciplinary research and constructive progress intended to break through disciplinary limitations. Here the benefits of ‘bridge building’ between diverse ecological sub-disciplines and ‘ladder building’ between scales are recommended alongside the proposal that social science should be integrated, interpreted and assessed in terms of a systems approach: to encompass scales (as relationships in patterns and processes), types of change (such as resilience, resistance, persistence and variability), classifications (of patterns and processes) and to assess human-ecological systems as self-aware, open, non-self-regulating systems, without stable equilibria subject to stochastic change and disturbances (Pickett et al. 1999).

For Campbell (2005), a social scientist working with conservation biologists, avoiding conflicts through differences in expectations (derived from alternative basic understandings of physical and human geographic disciplines) are the key to enabling the valued contributions that social science may bring to environmental science research. Rather than ‘bolting on’ social science components as a way of improving relations with local communities or enhancing advocacy, Campbell (2005) recommends anticipation in managing expectations, more even numbers of social and environmental scientists within interdisciplinary teams, plus the allowance of greater time to build common understandings through the integration of human with environmental science.

The basic qualities of interdisciplinary research are summarised by Turner and Carpenter (1999) as: the lack of an existing conceptual framework; a requirement for longer time frames (for successful outcomes from interdisciplinary team efforts) plus additional attention (for writing and reviewing interdisciplinary research) by authors and reviewers. To support the evaluation of interdisciplinary approaches observed through this research project, a summary of the essential components of interdisciplinary approaches, derived from the literature is proposed to guide the investigations reported within this thesis. The primary qualities of interdisciplinary approaches are therefore defined thus:

(i) have no clear framework or formula for delivery;

(ii) involve a multi-disciplinary team effort that takes longer to find common understandings;

(iii) require translation and interpretation between different languages and value systems;

(iv) demonstrate open and constructive approaches to identify novel solutions rather than succumbing to premature critical obstructions.

The following sections investigate the literature to review evidence for further challenges to interdisciplinary approaches and the potential solutions to support successful environmental and urban river restoration outcomes.

2.3.4 Environmental governance and socio-environmental complexity

The practical challenges of communicating between stakeholders and developing common visions for urban river restoration objectives frequently relate to different perceptions (e.g. of priorities, timeframes, etc) and the sheer complexity of multiple associations and interests. In terms of socio-environmental complexity, Giddens (1990) argues that the pace and the scope of change (spatial and social) also represent important characteristics of modernity i.e. the post-industrial era. While the pace of technological change has accelerated, a general expectation for simple solutions and rapid outcomes is frequently frustrated by the complexity of issues where urban environments are concerned. In relation to urban river restoration, not only are aquatic systems and the interactions between humans and rivers variable and complex, but contextual social and environmental changes alike may also be reactive and rapid (e.g. change of government, local flooding incidents), and closely related.

2.3.4.1 Complexity theory

The development of a ‘complexity theory’ and its application to areas of integrated research (Gallagher and Appenzeller, 1999) not only reflects the movement away from single disciplinary thinking in socio-environmental problem solving, but also provides a useful tool to consider where interdisciplinary governance might sit in relation to complex environmental and human systems. The associations drawn between order and disorder, linearity and random complexity, modernist and post-modernist epistemologies by Geyer (2003), when considered in the context of urban river management, provide valuable insights into some of the issues arising in relation to finding common understandings between the physical and social sciences (Tables 2.14 and 2.15).

The range of complexity exhibited by environmental and human phenomena when summarised in parallel (Table 2.14), begins to enable clarification of where the problematic issues for communication and knowledge exchange may arise and thus where facilitation may be usefully targeted. The philosophical parallels drawn by Geyer (2003) with the evolution of understandings from modern to postmodern paradigms associated with the natural and social sciences disciplines and human-nature relationships provides yet further opportunities to pinpoint incongruities. By expounding a new interpretation of the postmodern-modern boundary zone through a ‘Complexity’ paradigm, Geyer (2003) also offers the possibility of identifying new approaches to facilitate the integrated assessment and management of urban rivers.

Environmental scientists are increasingly demonstrating an engagement with ‘Complexity’, crossing traditional disciplinary boundaries to write about governance, ethics, economics and culture (O’Riordan, 2004; Booth et al. 2004; Matsuoka and Kaplan, 2008) to reframe the arguments and challenge the dominant paradigms that have effectively side-lined environmental concerns in the pursuit of economic growth (Giddens, 1990). The inherent integration that sustainable development agendas require also demand identification of ‘boundary’ issues and areas for development in generating

Table 2.14 The range of abiotic, biotic and conscious phenomena in a Complexity paradigm, based upon the model developed by Geyer (2003) and adapted to elucidate issues surrounding urban river management.

DISORDER	**Range of non-linear dynamic systems** ↔			**ORDER**
Alinearity	**Conscious Complexity**	**Biotic Complexity**	**Abiotic Complexity**	**Linearity**
ENVIRONMENTAL PHENOMENA				
Aspects of quantum mechanics & light; Random events	(n/a)	Plant and animal interaction / evolution; Gaia Theory	Fluid dynamics; Weather patterns	Gravity
HUMAN PHENOMENA				
Random events, dreams, the unconscious.	Norms; Values; Language; Narrative interpretation	Group dynamics; Institutional processes.	Crowd dynamics; Electoral outcomes; Economic laws.	Basic physiological functions: life/death
GOLDEN RULES				
		Partial order / chaos; Some phenomena (un)reducible; Partial modelling, prediction and control possible; General boundaries but uncertain outcomes.		
	Exibit adaptation & emergence.			
	Interpretation; Self awareness			

the ‘bridges’ and ‘ladders’ recognised as necessary to interdisciplinary work (Pickett et al. 1999).

2.3.4.2 Boundary issues

Highlighting again the issues surrounding perception and communication, overarching issues regarding the importance of communicating scientific knowledge between scientists and river managers, planners and decision-makers comes up repeatedly within the literature (Karr, 1999; Downs and Kondolf, 2002; Brierley, 2009; Wenger et al. 2009; Everard 2011).

Table 2.15 Summary of fundamental positions of Modern, Complexity and Postmodern science of relevance to challenges of interdisciplinary urban river management (Adapted from Geyer, 2003)

Postmodern	**Complexity**	**Modern**
EPISTEMOLOGICAL POSITION		
Relational;	Partial order;	Order;
Relational rationality;	Bounded rationality;	Rationality;
Unpredictable;	Predictability and uncertainty;	Predictability;
Irreducible;	Reductionism and holism	Reductionism;
Indeterminate	Probabilistic and emergent;	Determinism;
Relational interpretation,	Interpretative	Non-interpretive
RELATION OF PHYSICAL AND SOCIAL SCIENCES		
No clear relationship; Relational and interpretative nature of humanity makes clear relationship problematic	Integrative relationship; No separation necessary between physical and social sciences	Subservient/inferiority relationship; Social science strives to duplicate methods and results of physical science
RELATION OF HUMANITY TO NATURE		
Unclear relational distinction between humans & nature	Holistic interpretation of human and natural symbiotic co-evolution	Expanding dominance over nature
METHODOLOGICAL IMPICATIONS		
Relational interpretations; Undermining fundamental ‘truth’ claims	Integration of experimentation and interpretation; Fundamental laws and distinctive outcomes.	Experimentation, quantification; Search for fundamental laws.
VISION OF PROGRESS		
No fundamental order; Pure knowledge creation and progress is impossible to know; History is relational and does not universally progress	Significant limits to knowledge and progress due to complexity and uncertainty; History may progress and display fundamental patterns but is also uncertain and tortuous.	No inherent limits to human knowledge and progress exist; History is progressive, cumulative and leads to an ultimate end point.

Two key issues for sustainable development and expectations for knowledge exchange at the boundary between inter-connected social, economic and environmental processes within urban environmental regeneration agendas are identified by Raco and Dixon (2007). Firstly, the fundamental role of environmental science in monitoring, managing and mitigating environmental change, plus informing governance and decision making processes is acknowledged. Secondly, the ‘breaking open’ or reframing decision-making processes to include both experts and non-experts; to recognise the ‘plurality’ and value of different types of knowledge is found to be of key importance. Where these processes are hindered by shortfalls in translation, facilitation is highlighted as fundamental to mediating between different disciplines and (non)experts.

A series of exchanges between a range of disciplinary experts and practitioners reported by James et al. (2009) identify two further issues relating to urban greenspace regeneration, again reflecting the complexity of multi-disciplinary and information exchange boundary issues. Firstly, the lack of integration of the understanding of greenspace function into planning, design and management processes; and secondly, the lack of ‘reliable and robust’ approaches to urban greenspace valuation to support decision making. To meet these concerns, proposals include the creation of a robust evidence base, accessible to academics and practitioners alike to support decision making for urban greenspaces, also echoed by Cornell (2010).

2.3.5 Conclusions for Urban River Environmental Governance

The literature provides many observations and suggestions relating to the challenges of managing complex socio-environmental regeneration/restoration management issues, and in particular those arising at the boundary between social, environmental and economic processes. The interfaces between social and natural science research, and quantitative and qualitative methods highlights for several authors the need for more tolerance and understanding (Liverman and Roman-Cuesta, 2008); less critical and more constructive approaches (Pickett et al. 1999).

The significance of the theoretical frameworks described in this section (for partnership, integration and complexity) represent important challenges for river practitioners in their work to meet the assessment and management challenges for urban rivers described in sections 2.2.5 and 2.3.1.5. Further investigation of these issues is provided through the assessment and case study evidence reported in Chapters 4 and 6.

2.4 Valuation of urban rivers

The burgeoning academic and grey literature regarding environmental valuation, ecological economics and ecosystem services assessment demonstrates current levels of motivation towards focusing environmental issues within economic debates. This section is specifically concerned with the relationship between ecological valuation, urban river ecosystem services and resourcing urban river restoration schemes.

Fundamental issues exist between the benefits provided by urban rivers to society, how urban river restoration is regarded by potential sponsors and therefore how urban river restoration is resourced by stakeholders and society. A lack of formal state funding arrangements to cover the substantial costs of planning and delivering urban river restoration demands investment from a range of sponsors. The complexity of governance models described in section 2.3 includes a primary need for financing strategies that may combine strategic urban planning and opportunistic sources. The ability to demonstrate positive cost:benefit outcomes to sponsors is often an important aspect of attracting funding to environmental projects such as urban river restorations. This section aims to provide an overview of the literature describing the importance of understanding urban river services and their values (section 2.4.1), the background to ecological valuation mechanisms currently in use (sections 2.4.2 and 2.4.3), plus some examples of direct relevance to urban river restoration planning and management (section 2.4.4). A summary of the main issues for valuing urban rivers is provided in section 2.4.5.

2.4.1 The value of urban rivers and their valuation

The successful establishment of numerous towns and cities is typically associated with the presence of nearby river systems and the essential services they provide to human populations (Everard and Moggridge, 2011). Throughout history, a dependence upon freshwater supply for drinking water, agriculture and industry has led to the transformation of valley floors into a built environment (Baschak and Brown, 1995). In recent history, public awareness of the fundamental links between civilisation and natural river functioning has been largely erased, both conceptually and physically, by extensive engineering and culverting of rivers (Barton, 1962, Tapsell, 1995). Often, there is greater public awareness of the risks rather than the benefits presented by rivers as popular news media highlight flooding incidents where over-engineered rivers, disconnected from floodplain or upland storage opportunities dramatically overspill into developed areas, damaging residential and commercial centres and bringing high financial and human costs (Green et al. 1991, Brown and Damery, 2002).

The essential services provided by urban rivers and floodplains range from provisioning (e.g. fresh water supply); to regulating (e.g. drainage or storage excess quantities of flood waters). Equally vital but less obvious regulatory benefits include heat island cooling effects; air quality improvement; carbon capture via riparian vegetation (fast growing willow sp., reeds etc); and water purification processes (via saprobic organisms); building ecological resilience, and maintaining the balance of species and habitats. Where aquatic ecosystems exist as part of public greenspaces, additional cultural and social benefits also encompass a huge range of associated services such as: mental health benefits; healing promotion; social cohesion; improved community integration; reduced fear of crime; a social focal point; leisure and fitness opportunities; educational opportunities; e.g. awareness of climate change and adaptation (Tzoulas et al. 2007, Everard and Moggridge, 2011).

Despite localised pockets of appreciation for less heavily impacted reaches e.g. for angling and other forms of recreation, negative public perceptions develop where urbanised rivers display environmental problems (Silva, 2004). However, after centuries of engineering modifications designed to control and utilise natural river functions, increases in integrated political and environmental awareness are now delivering mechanisms to enable rivers and aquatic ecosystems to be included in decision making. The powerful ‘ecosystems approach’, described in the 2009 EA Science Report: ‘Ecosystem services case studies’ as: *‘..a planning paradigm, founded on the basis of ecosystem services and the optimisation of benefits’* has been adopted and ‘championed’ by Defra, ‘*as a basis for more sustainable and inclusive policy formulation in England*’ (Everard, 2009, Defra, 2010a). The opportunity to acknowledge and rank ecosystems alongside economic interests in planning decision making processes, represents major progress for environmental management and sustainable development. A concise review of the literature describing the succession of key landmarks which have facilitated these advances is provided in the next section.

2.4.2 Brief history underlying ecosystem services valuation

While the many services provided by urban rivers to society may be clear to river experts and some developers (through their value in ‘revisioning’ city environments, Pinch and Munt, 2002), a standardised means of communicating these to wider audiences was elusive until the landmark publication of the United Nations Environment Programme (UNEP) sponsored Millennium Ecosystem Assessment (MA, 2005a, 2005b).

The literature again reflects the parallel course in the development of integrated ecosystem awareness, sustainable development and ecological economics with key publications marking conceptual landmarks through the course of the 20th century (Table 2.16). From the 1960s onwards, concerns expressed by environmental and social experts regarding human impacts, species extinction and resource depletion were highlighted both in academic and more publically accessible sources (Carson, 1962; Hardin, 1968; Meadows et al. 1972; Schumacher, 1973; Ehrlich and Mooney, 1983). The introduction of sustainable development principles by Brundtland (1987) emphasised the need to integrate social, economic and environmental factors to find sustainable solutions to an international audience. Although largely driven by issues of food security and genetic resistance within monocultures, following the adoption of the 1993 Convention on Biological Diversity (CBD), the UNEP Global Biodiversity Assessment (plus summary for policy makers) (Heywood, 1995, Watson et al. 1995) sought to fill further perceived knowledge gaps about ecosystem function.

Rather than focusing purely at the species level, the farsighted UNEP assessment included genetic, community and landscape diversity and their contributions to the provision of ecosystem services (Mooney and Ehrlich, 1997). Another landmark publication by Constanza et al. (1997), estimating the economic value of 17 ecosystem services in 16 biomes at an average value of $33 trillion/yr, sparked widespread debate regarding approaches to ecological valuation including critiques of the methodological limitations of drawing upon numerous smaller studies to generate globalised estimates (e.g. Toman, 1998, Bockstael et al. 2000). Further criticisms by ecologists of using neo-liberal approaches to environmental conservation and the risks of obscuring ecosystem function by commodifying ecosystems reflect pockets of resistance to the introduction of economics to ecological debate (Peterson et al. 2010, Cornell, 2011).

Emerging from the disparate literature of the 1990s, early classifications of ecosystem service type (e.g. de Groot et al. 2002) became formalised through the Millennium Ecosystem Assessment (MA, 2005a, 2005b). The publication of the MA established a standardised method for valuing or evaluating ecosystem services (Table 2.17) at the international level. The MA provided a universal framework for practitioners to begin developing techniques for costing goods and services under four broad categories: Provisioning, Regulatory, Cultural and Supporting (later changed to Habitat) services (TEEB, 2010a).

Table 2.16 Landmarks for environmental valuation and UK development of Ecosystem Approach – 1960s to present, identified within the literature

Year	**Landmark publication or event**
1962	Carson (1962) – 'Silent Spring' - *highlighted importance of ecological systems and indirect human impacts*
1968	Hardin (1968) - 'Tragedy of the Commons'
1968	Erlich (1968) – 'The Population Bomb'
1972	Meadows et al. (1972) Club of Rome - 'Limits to Growth'
1973	Schumacher (1973) – 'Small is Beautiful' – *highlighted concept of 'natural capital'*
1983	Ehrlich and Mooney (1983) – 'Extinction, substitution and ecosystem services' *introduced concept of ecosystem services as 'the benefits to humans that well-functioning ecosystems provide'*
1987	Brundtland (1987) – 'Our Common Future' – *introduced concept of sustainable development*
1992	Rio Earth summit – *International agreement by signatories to follow sustainable development principles outlined in* 'Agenda 21'
1995	Heywood (1995); Watson et al. (1995) – UNEP Global Biodiversity Assessment
1997	Constanza et al. (1997) – *first attempted valuation of global ecosystem services*
2005	UNEP Millennium Ecosystem Assessment (MA, 2005a)
2005-2008	Defra – Ecosystems Approach and Natural Environment Strategic Research Programme launched – *to establish basis for ecosystem approach,* Synthesis of research gathered through Defra's Ecosystems Approach and Natural Environment Strategic Research Programme
2007	'Potsdam Initiative' for biodiversity launched by G8+5 countries, including 'The Economics of Ecosystems and Biodiversity' (TEEB) study to analyse (i) the global economic benefit of biodiversity, (ii) the costs of biodiversity loss and failure to take protective measures vs conservation costs (Cornell, 2010) – Securing a healthy natural environment: An action plan for embedding an ecosystems approach (EAAP, Defra, 2007b) - Introductory guide to valuing Ecosystem services (Defra, 2007c) - Preliminary Cost Effectiveness Analysis (pCEA) of the EU Water Framework Directive (Defra, 2007d)
2008 - 2010	Defra publications: – Delivering a healthy natural environment - An update to "Securing a healthy natural environment: An action plan for embedding an ecosystems approach" (EAAP update) 2010 - Towards a deeper understanding of the value of nature: Encouraging an interdisciplinary approach towards evidence about the value of the natural environment (Oct 2010)
2010	Defra's Evidence Investment Strategy 2010-13 (Defra, 2010b)
2010	TEEB reports published (e.g. TEEB, 2010a, 2010b)
2011	UK National Ecosystem Assessment (NEA) – Launched June 2011
2011	Defra - Natural Environment White Paper

Table 2.17 Ecosystem Services provided by river systems and sorted by type (Adapted from: MA, 2005a; Everard, 2009, Vaze et al. 2006).

Ecosystem Service type	River system ecosystem service
Provisioning Services	– Potable / non-potable water supply; fish / shellfish / edible macrophytes
Regulating Services	– Waste and excess water drainage; flood storage abd control; Water quality remediation and self-purification ; Climate control and climate change mitigation
Cultural Services	– Recreation in and around water; aesthetic; spiritual; environmental education; human-nature connectivity; amenity; art and symbolism; well-being: mental health.
Supporting Services	– Water recycling, nutrient cycling, primary production, provision of habitat e.g. soil formation on flood plains

This major shift in political and planning approach and sudden upsurge in interest in communicating in terms of ecosystem services has since formed the basis of many international ecosystem services studies (TEEB, 2010b see also UNEP interactive global map http://discomap.eea.europa.eu/map/environmentalatlas/) including the UK National Ecosystem Assessment Study (UK NEA, 2011a, 2011b). The particular significance of ecosystem service recognition and valuation for urban river systems, is closely related to the local and regional scales of: (i) social dependency and opportunity, alongside (ii) the high potential for synchronised enhancement of ecological (e.g. biodiversity) and socio-economic benefits.

2.4.3 Approaches to valuing urban river ecosystem services

A brief overview of the literature relating to methods of valuing ecosystem services reveals some important developments in recognising the opportunities and limits of conventional economic approaches.

The parallel development of ecological economics, evolving since the 1960s in response to rising socio-environmental concerns has sought ways to adapt traditional policy instruments to sustainable development principles and provide mechanisms to counter the failure of economic systems to ‘maximise human wellbeing’ and environmental quality (Pearce, 2002, Ropke, 2004). However, the application of economic approaches to complex and dynamic ecological systems has been problematic for many ecologists especially when valuation approaches address only those ecological functions which benefit humans and disregard other intrinsic functions (Peterson et al. 2010). While a degree of ecosystem valuation involving pricing or ‘monetising’ assets or services may be viable using traditional approaches, major limitations for many indirect benefits gained by society, e.g. mental health or quality of life, are also acknowledged in many reports (TEEB, 2010a, Everard and Moggridge, 2011). In such cases, alternative methods of evaluation or appraisal of such benefits using non-monetary values are called for and highlighted as areas of research need (Peterson et al. 2010) An early Defra research output, collating research on the value of the environment, simply states:

> *‘… while we may be able to reduce uncertainty through better science and economics, valuation, in general, cannot offer a full “solution” to the problem. Uncertainty is something we have to live with.’* (Eftec, 2006 p. 38)

Different choices for economic valuation, illustrated by TEEB (2010a, Figure 2.3) and defined by Kaval (2010, Table 2.18) include market and non-market valuation methods (e.g. willingness to pay, travel cost etc) although contingent and group valuation have also been considered (de Groot et al. 2002, Bateman et al. 2006). Most recent international research by TEEB (2010a, 2010b) advocates an open and flexible approach to the final stages of capturing value of ecosystem services *‘for every decision the context is different, hence there is no single valuation process that can be prescribed for every situation’* TEEB, 2010a p.13. As such, the TEEB approach aims to capture the ‘plurality of values’, recommending the use of *‘best available estimates of value for a given context’*. Where ecological aspects are defined as ‘difficult to capture’ in valuation, the TEEB report recommends that this information is presented alongside other valuations. Furthermore, a failure to seek ways to internalise valuation in decision making is deemed unacceptable, and emphasised thus:

> *‘.. namely, to permit the continued absence of value to seep further into human consciousness and behaviour as an effective ‘zero price’, thus continuing the distortions that drive false trade-offs and the self-destructiveness that has traditionally marked our relationship with nature’* (TEEB, 2010a p.12)

The numerous challenges of applying both standard economic tools and the MA framework to UK river restoration projects are highlighted via EA case studies on the River Tamar and Alkborough Flats (Everard, 2009). Lessons learned through these studies highlight the methodological shortcomings and areas of research need especially in relation to issues surrounding climate change (e.g. carbon sequestration) and human health benefits (summarised in Box 2.4).

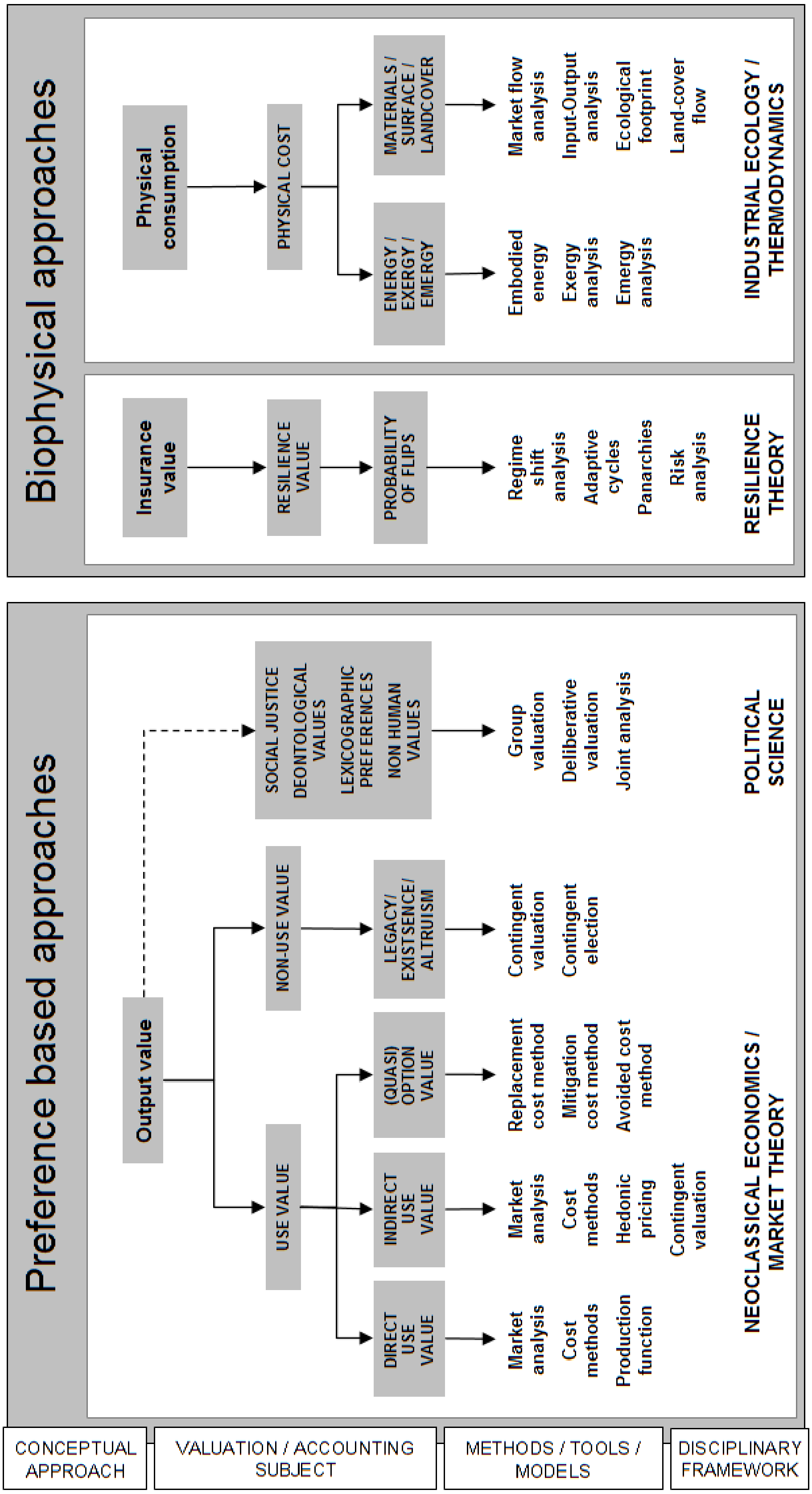


Figure 2.3 Summary of different types of ecosystem service valuation approaches. (Source: TEEB, 2010a)

Table 2.18 Different types of economic valuation (Adapted from TEEB, 2010a; Kaval, 2010)

Valuation method	**Description**
Market values	Current cost of goods or services purchased on the open market
Contingent valuation method e.g. Willingness-to-pay or Willingness-to-accept (cost)	Stated preference method: amount a person would pay under hypothetical circumstances
Travel cost method	Revealed preference method: amount paid for a specific trip
Choice experiments	Stated preference method involves questionnaires to discover persons preference for alternative management strategies
Hedonic pricing	Revealed preference method: investigates price paid for specific goods in relation to environmental benefit e.g. house with view
Benefit transfer or value transfer	Method relies upon transferral of secondary data to subject area (policy site) where time or budget limitations prevent primary data collection or calculations.
Avoided cost method	Aims to quantify the costs not incurred when services are provided by ecosystems, e.g. value of lost services if an ecosystem is destroyed
Replacement cost	Cost of replacing an ecosystem service by artificial product or process
Restoration cost	Cost of restoring an ecosystem to natural state prior to environmental damage, e.g. following a polluting incident
Factor income	Value of ecosystem service that enhances market value ecosystem service e.g. bees pollinating market produce.

Since 2006 evidence based strategies initiated by Defra are generating case studies and examples of ecosystem services applications, many of which are accessible online within the public domain (Defra, 2010b – Evidence Investment Strategy 2010-13). The focused investment and transparency of evolving programmes is generating a rapid uptake. As applications of the ecosystem approach and eco-services concepts proliferate rapidly at the international scale, a precautionary note is provided by Cornell (2010) in relation to lessons learned from early applications of environmental economics to dynamic and functioning ecological systems, by summarising the risks as:

(i) a narrowing of focus onto the monetary value of ecosystem services, rather than more integrative or plural assessments of value;

(ii) a conceptual disconnection of value from dynamic functions, modular processing and losing sight of the value of *whole* ecosystem functioning;

(iii) a paucity of data.

However, the value of interdisciplinary, meta-debates between research bodies and exchange of case study evidence are regarded overall as a positive contribution to ongoing ESA discourses and development.

Box 2.4 Summary of research gaps and lessons learned from EA Case studies at reach and catchment scale (Adapted from Everard, 2009)

Simple procedures needed for assessing net contributions of reach scale restoration works to:

1. Climate Change regulation e.g. via carbon sequestration
2. Fish recruitment
3. Air quality regulation (PM10s, SOx, etc); microclimate
4. Catchment scale hydrology
5. Supporting processes e.g. soil formation, primary and secondary production; nutrient cycling, pest control, pollination.
6. Net societal value

Additional tools/mechanisms needed:

1. Database of transferable benefits
2. A collaborating network of partner organisations
3. Engagement of more diverse stakeholders in valuation to reflect different objectives
4. Identification and valuation of interactions between services
5. Identification of the scale of each service

2.4.4 Ecosystem services assessment in practice and relevance to urban river restoration.

The wealth of landmark publications since the mid-2000s to date reflects the huge investment by (inter)disciplinary experts to generate and review evidence of the ecosystem approach and eco-services valuation. The UK National Ecosystem Assessment (UK NEA, 2011b) compiles contributions from disciplinary experts to provide descriptions and tentative costs for UK ecosystem services to underpin Defra's ecosystem approach strategy. Of the four summary outputs provided online by Defra, two highlight the estimated (‘*worth up to’*) benefits contributed by inland wetlands to water quality (£1.5billion per year) and amenity (£1.3billion per year) (see Box 2.5).

Box 2.5 Summary outputs from UK National Ecosystem Assessment provided online by Defra
(www.defra.gov.uk/news/2011/06/02/hidden-value-of-nature-revealed/)

- The benefits that inland wetlands bring to water quality are worth up to £1.5billion per year to the UK;
- Pollinators are worth £430million per year to British agriculture;
- The amenity benefits of living close to rivers, coasts and other wetlands is worth up to £1.3billion per year to the UK; and
- The health benefits of living with a view of a green space are worth up to £300 per person per year.

Given the lack of consensus and ongoing development of ecosystem valuation techniques (TEEB, 2010a), both public and academic publications depend upon the application of expert judgements and specialist knowledge especially at the highest spatial scales. Within these decisions about valuation methods, or which details to include or omit, also lie the ‘bounded rationality’ and ‘reductionism and holism’ characteristics associated with complexity theory by Geyer (2003, see Table 2.15) which are now demanded of the scientific community itself.

At the local scale, limitations regarding knowledge of the full range of ecosystem service benefits to society which may be derived, (e.g. from an urban river restoration), means that project related ESA reporting is most likely to provide an underestimate of the cost:benefit ratio. For example, the trial Mayesbrook Project ESA, representing a first urban aquatic ecosystem ESA attempted in England, estimated an overall benefit-to-cost ratio of 7:1 (and proved to be of major interest to policy makers), but substantial knowledge gaps and areas of research need were highlighted through the process, particularly in relation to climate change mitigation, cultural and health benefits (Everard et al. 2011).

The importance of establishing protocols for especially complex urban river valuation approaches emerges as an under researched interdisciplinary priority (Everard and

Moggridge, 2011). Corresponding progress in the ecological valuation of urban greenspaces and trees has generated several useful examples and tools such as CAVAT (Neilan, 2008) and iTree (www.itree.org) which may also potentially benefit urban riparian and floodplain valuations (see Box 2.6).

Box 2.6 Urban Greenspace and Tree evaluation – examples of progress

Greenspace valuation

Natural England document ‘Nature Nearby’ (Natural England, 2010) sets out Accessible Natural Greenspace Standards (ANGSt) and highlights links with:

- key benefits of ecosystem services e.g. securing biodiversity, health and wellbeing, climate regulation (p.19-20)
- reductions in costs of infrastructure, social and health services (NE, 2010, p. 7).
- guidance on securing funding streams through partnership (p.43)

CABE study ‘Making the invisible visible’ (CABE, 2009) highlighted the value of parks and greenspaces, the need for simple mechanisms and a suggested framework for park valuation.

Tree valuation

International investment by forestry and woodland organisations has already developed a range of tools to value urban trees e.g. CAVAT (Neilan, 2008) and i-Tree (www.itree.org). Reviews by the Forestry Commission in 2008 and 2010 indicate different strengths for each method but fundamental limitations associated with data shortages, lack of social valuation and subjectivity in analysis (Trees and Design Action Group, 2008; Forestry Research, 2011)

2.4.5 Conclusions for urban river valuation

The high levels of interest in environmental valuation and ecosystem services are currently generating a huge amount of literature and debate over methods of valuation. Overall, issues relating to shortages of data or evidence and the need to link science with policy and decision making provide common themes (TEEB, 2010a; Cornell, 2010; Everard, 2011). Many papers and reports are already providing valuable evidence to inform progress, and one of the main challenges for practitioners will be to integrate or filter the findings of individual studies to identify the best fitting methods for projects.

Even though ESA figures undoubtedly represent underestimates, the political interest in such valuation methods reflects the need to justify spending, whilst at the same time perpetuating dominant neo-liberal paradigms and the risks of commodifying ecosystems and detaching ecological functioning from human-focused services. Meanwhile, early evidence suggests that if current funding mechanisms are successfully stimulated by a synthesised ‘neo-eco-liberal’ approach, and investment in sustainable environmental projects is justified by ecological economics, there is a chance for ecosystems to hold their own within development discourses and applied decision making, and ultimately benefit ecologically.

The contested, multi-dimensional and context-dependent nature of the terms ‘biodiversity’ and ‘value’ make defining ecological and ecosystem service valuation highly complex and open to a wide range of interpretation. NERC research found valuation pathways to be dominated by either social or natural sciences, and a need for an interdisciplinary rebalancing through more integrated approaches (Raffaelli et al, 2009). Despite the tensions and complexity of the emerging ecosystem paradigms, the wealth and responsive characteristics of the literature suggest that the ecosystem approach and services discourses, as an active ‘melting pot’ of interdisciplinary practical and conceptual development, will continue to generate new ideas and progress rapidly. However, only when the outcomes have been lived for a number of years will the evidence and reflections deliver retrospective evaluations of these approaches. The ongoing integration of experimentation and reflective interpretation processes highlighted by Geyer (2003) needed for this integration is recognised by Cornell (2010) as a stronger tradition for social scientists, thus placing them a key role in providing direction for natural scientists within these new philosophical territories.

The relevance for urban river management and financing of urban river restoration lies within the ability of river practitioners to make a case to attract investment and sponsorship towards ecologically beneficial projects. However the links between ecosystem valuation and investment in environmental restoration are not yet explicitly demonstrated. A combination of primary and secondary evidence gathered through this research project will be analysed to investigate the connections between the understanding and demonstration of ecosystem services and financing in practice. The results of these analyses are presented in Chapters 4 and 7.

2.5 Conclusions of literature review regarding assessment, planning and managing urban rivers and research questions

This chapter has reviewed literature covering three contextual areas of relevance to interdisciplinary approaches to urban river restoration including: the ecological context - bio-physical river assessment (section 2.2); the environmental governance (i.e. social) context - partnership working, integrated management and complexity (section 2.3); and the economic context - valuation of urban rivers (section 2.4).

2.5.1 Summary of findings

The literature reviewed has highlighted many issues about disciplinarity, boundaries and the integration of many components required for sustainable environmental management and development. Based upon the literature review, summary findings indicate the following key points:

- Disciplinary knowledge of river systems is essential, either as reductive or expansive science, in building understanding of urban catchments and providing essential concepts and methods (as tools) thus enabling practitioners to design and manage ‘with nature’ in a variety of environmental surroundings.
- Recent progress in developing connectivity between disciplines is ongoing and responsive to recognised and acknowledged needs to meet the demands of sustainable management of urban river systems.
- Physical and social disciplines are each willing to collaborate but philosophical conditioning, the complexity of socio-environmental issues plus the extra time and efforts required present obstacles to be overcome, demanding extra skills and resources.
- The integration of environmental, social and economic components of sustainable development is a ‘live’ process, currently actively managed through programmes like Defra’s ecosystem approach. Demonstration of the benefits for urban river systems requires evidence and further research at local and regional scales
- Evidence strategies will in time provide invaluable bases for future development, however urban river restoration presents a complex mosaic of

> interests and variables, and practitioners will need to acquire skills to manage the complexities of integrated and coordinated sustainable development

This thesis will examine the evidence for progress in applying interdisciplinary approaches to the assessment, planning and management of urban rivers in London, through multi-disciplinary partnership delivered restoration projects.

Knowedge gaps emerging from the literature review are identified in relation to the effectiveness of multi-disciplinary partnerships in financing and delivering combined socio-environmental objectives through urban river restoration and restoring physical and ecological function to urban rivers. There is also a lack of clear guidance regarding which kinds of approaches and tools are most effective in supporting practitioners to deliver sustainable and ecologically successful restoration works and enhanced ecosystem services through integrated urban river projects.

2.5.2 Research Questions

The issues highlighted by the review of literature therefore raise some important research questions which are investigated through this thesis:

1. To what extent can ecologically successful and cost-effective river environment improvements be achieved through combined socio-environmental[1] approaches to urban river restoration?
2. To what extent are current environmental governance models and multidisciplinary partnerships able to deliver benefits for urban river environments and enhanced ecosystem services through urban river restoration projects?
3. To what extent can integrated anthropo-environmental[2] assessments of urban rivers (such as URS and ESA) provide tools to share knowledge and support decision-making for urban river restoration projects and support the delivery of environmental policy objectives?

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[1] The term ‘socio-environmental approaches’ is used here to refer to approaches that integrate social with environmental objectives

[2] The term ‘anthropo-environmental’ is used here to refer to the combined assessment of the anthropogenic influences or outcomes in association with the environmental condition of urban river systems

4. To what extent are existing environmental information resource bases and knowledge exchange processes providing support to multi-organisational partnerships in planning and delivering integrated socio-environmental projects?

Chapter 3: Methodology

3.1 Introduction:

The purpose of this chapter is to introduce and discuss the research methods employed to gather and analyse data for the environmental, social and interdisciplinary investigations carried out in this thesis. Urbanised environments are characterised by a range of artificial anthropogenic physical attributes, including impermeable land cover and river channelization, which may operate singly or in combination to alter catchment hydrology, geomorphology and aquatic ecology (Shaw, 1983; Chin 2006; Walsh et al. 2005). The combined natural and artificial components of urban catchments create unique hybrid urbanised ecological conditions driven by a spectrum of variables and potential interactions. In addition, diverse social interactions within and between the local human (residential and practitioner) communities and urban rivers also carry the potential for both negative and positive impacts on the condition of urban aquatic environments. The combination of semi-quantitative and qualitative methods selected for this research project together provide evidence to enable an investigation of interdisciplinary approaches to the assessment, planning and management of urban rivers and restoration practices.

The multi-method approach applied in this thesis involves several (inter)disciplinary components which integrate environmental, anthropogenic and social factors in different ways. This enabled the researcher to gain greater understanding of the river and human research subjects through triangulation by considering observations from different perspectives (Flick, 2004). Investigations undertaken at regional and local scales facilitated the comparative analysis of factors operating at different bio-physical and governance levels. The range of methods applied to the research subjects provided a diverse knowledge base from which to answer the research questions identified in section 2.5.2.

As a whole, the research project covers four interconnected components undertaken in parallel, each delivering a different (inter)disciplinary perspective on urban river assessment, planning and management. Figure 3.1 provides a conceptual model of how the chosen methods are applied in parallel to the research subjects. This chapter explains the rationale behind the choice of the methods and considers the strengths and limitations of each.

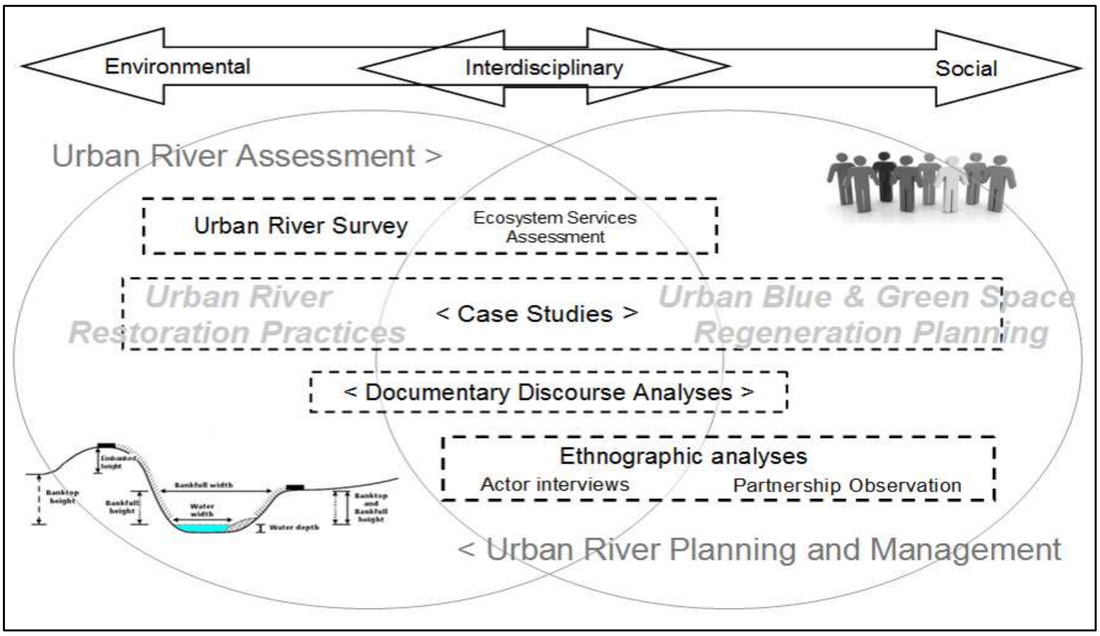


Figure 3.1 Conceptual model of methods applied to investigate the environmental, interdisciplinary and social aspects of research subjects

Section 3.2 begins with a description of the Urban River Survey method (URS, Davenport et al. 2004): the primary environmental science method used to investigate the bio-physical habitat qualities and habitat:engineering interactions of London urban rivers. Section 3.2.1 provides the rationale for the selection of the URS method and a review of its strengths and limitations, and. Section 3.2.2 provides a description of the URS data analysis techniques including the generation of aggregated indices, classification and principal component analysis.

The London regional and local scale study areas are introduced in section 3.2.3. This section describes the approach used in a series of catchment and reach scale investigations of London river habitat quality using the URS primary data. Further analyses of secondary regional data obtained from the River Restoration Centre (RRC) and London Rivers Action Plan (LRAP) databases relating to historic restoration planning and management are also described. Section 3.2.4 describes the development of the URS method through this research project to facilitate data collection and understanding of urban river qualities for a range of stakeholders. This section includes a brief summary of the URS training workshop organized as part of this research project. In contrast to the environmentally-focused URS, section 3.3 describes the Ecosystem Services Assessment method which is concerned with the valuation of environmental ‘goods and services’ and the benefits to society associated with urban river restoration.

Section 3.4 introduces the role of the case study approach in providing first hand environmental and social science data relating to recent and historic urban river restoration projects. The objectives for this integrated method are outlined alongside a review of the advantages and limitations of using case studies. Section 3.5 presents an overview of the documentary discourse analysis of key drivers for urban river restoration and integrated urban river governance.

Section 3.6 next introduces the range of ethnographic analytical methods used to investigate the governance and multi-disciplinary partnership approaches to urban river restoration planning and delivery in Greater London. This section provides the rationale (section 3.6.1) and techniques (section 3.6.2) employed, including participant observation of planning partnerships and interviews with key actors involved in urban river restoration in London. A description of the qualitative analysis of the ethnographic data is given in section 3.6.3.

The concluding section (3.7) provides an overview of the methods described and considers these in relation to ‘wicked’ problem solving and use of hierarchical matrix approaches to urban river assessment, planning and management.

3.2 Urban river bio-physical assessment

As described in Chapter 2, within the environmental sciences interdisciplinary river assessment methods have become increasingly well established over the last few decades (e.g. hydro-ecological method, PHABSIM), providing new integrated knowledge of complex natural systems. The relatively recent inclusion of anthropogenic factors within integrated anthropo-environmental assessment methodologies extends earlier models beyond the multiple components of complex natural systems, to gain an understanding of the inter-relationships (connections, responses and feedbacks) between natural and artificial variables. The Urban River

Survey (URS, Davenport et al. 2004) method provides important information about the bio-physical condition of urban rivers in relation to human impacts. The following section introduces and rationalises the application of the URS method in this thesis.

3.2.1 Urban River Survey

3.2.1.1 A brief history and description of the Urban River Survey

During the early 1990s the National Rivers Authority recognised the need for a methodology to classify rivers according to their physical habitat characteristics. Since 1994 the River Habitat Survey (RHS, Raven et al. 1997) has provided a standardised classification methodology for physical river habitat across England and Wales (Raven et al. 1998) and is the primary physical assessment methodology used by the Environment Agency (EA) for Water Framework Directive (WFD) classification of river morphology. When first developed, the primary objective of the RHS was to produce an inventory of the baseline reference conditions for all river types in England and Wales. The RHS classification of pristine river reaches and associated habitats was designed to be used: (i) as a reference for the assessment of conservation value of the aquatic habitat for each river type and (ii) to provide a framework for river management that would function at the catchment scale within a regional and national context (Raven et al. 1998; Fox, et al. 1998).

The RHS database holds over a million records for river reaches across a variety of rural and semi-rural catchments and is quality assured by the requirement for surveyors to be accredited by the Environment Agency. However, some limitations to the method, in particular relating to modified channels, were soon recognised (Raven et al. 2000). RHS reaches within urban catchments typically fall into the lowest quality categories as some important habitat features are ‘lost’ or unrecorded where they fail to meet the strict RHS criteria, e.g. if under-sized or associated with artificial influences such as bridge pedestals (RHS training, pers comm.). An opportunity to modify the RHS methodology and increase the sensitivity for urban river habitat assessments was realised through PhD research completed in 2001 (Davenport et al. 2001). The Urban River Survey method was demonstrated in 2002 via the EU LIFE Environment project: SMURF (Sustainable Management of Urban Rivers and Floodplains) (Environment Agency et al. 2003); and calibrated through post-doctoral research on English and European urban rivers (Davenport et al. 2004, Gurnell et al. 2007).

The Urban River Survey (URS, Davenport et al. 2004) represents a modification of the standard RHS methodology (Raven et al. 1998) which has been adapted for urban or highly modified rivers and streams. The URS follows the same format as the RHS whereby each survey provides data for a standard 500m reach, through observations at a series of ten equally spaced 'spot checks' where qualitative details of key physical (geomorphological) and vegetation habitat features are recorded. These data are supplemented by further cumulative or 'sweep-up' data recorded along the whole survey stretch. The cumulative data include counts and proportional estimates (as percentage lengths or areas) of physical habitat features and modifications within the channel and riparian corridor, in order to record features falling between spot check locations as well as overall proportions of features which are continuous by nature. The URS uses the same basic definitions of river habitat characteristics to ensure consistency with the original RHS method. However, some URS recording 'rules' are modified for features which are (a) small but providing important functional habitat and (b) associated with artificial influences (e.g. a mid-channel bar formed due to the presence of a shopping trolley is recorded within the URS).

The most important and fundamental difference between the two surveys is the definition of the URS survey reach or 'stretch' which is identified by the dominant engineering type and recorded in terms of planform, cross section and level of reinforcement (see Table 3.1). The URS is designed to assess 500m stretches of urban rivers, defined by a single engineering type, but may also be applied to shorter stretches (to a minimum of 300m) if constrained by access or engineering extent.

The URS survey records 14 separate groups of data (summarized in Table 3.2), including all of the RHS components plus additional indicators of physical modification, anthropogenic impacts and increased detail for vestigial habitat features that offer important niches within urban landscapes e.g. percentage of flow types within channel transects. In contrast to the RHS, the collection of data regarding the type and extent of channel engineering, pollution indicators and invasive species; plus further details for riparian land-use, which may be linked to poor water quality from contaminated run-off, represent important anthropogenic variables captured within the URS. A set of URS survey forms is provided in Appendix A.

Table 3.1 Engineering types, codes and definitions (Source: Gurnell et al. 2011)

Planform	**Cross-Profile**	**Level of Reinforcement**
Engineered Straight, ST *(engineered to a straight planform)*	Enlarged, EN *(cross section made substantially wider and/or deeper than a naturally-adjusted channel would be at the same site)*	No reinforcement, NONE
Engineered Sinuous, ME *(engineered to a sinuous planform)*	Two-stage, TS *(cross section includes a flood channel with an inset smaller channel to accommodate non-flood flows)*	Bed reinforced, BED
Recovering, RC *(engineered straight or sinuous but showing significant planform readjustment induced by fluvial processes)*	Re-sectioned, RS *(cross section reshaped to a more efficient trapezoidal form)*	One Bank reinforced, ONE
Semi-natural, SN *(no obvious sign of engineering of the planform)*	Cleaned, CL *(flow resistance reduced through removal of roughness elements such as trees and shrubs and minor morphological irregularities)*	Bed and one bank reinforced, BED ONE
	Restored, RE *(cross profile form designed as part of a restoration scheme)*	Both banks reinforced, TWO
	Semi-natural, SN *(cross profile form shows no obvious signs of engineered modification / has completely recovered from historical engineering)*	Full reinforcement, FULL

During the process of developing and streamlining the URS method, the recorded data were sorted to identify the ‘essential’ recorded data i.e. those used in the calculation of the URS indices (Figure 3.2, column 2). Further ‘optional’ data (column 3) represent those observations which may be recorded according to user interest or extended by the addition of more user-specific data (e.g. MSc investigation of URS in relation to Water Vole habitat, Gomes, MSc thesis 2011). Further detail of the URS method development is provided in section 3.2.4.

Table 3.2 URS data recorded during field survey. Additional URS data or detail in recorded values (compared to RHS) are shown in ***bold type***

URS data subsets	URS Essential Data	URS Optional data
'One off' data		
1. Survey details	River name Surveyor name Date / Time	**URS stretch ID code** **URS stretch name** **EA WFD ID** **Sector code** Surveyor accreditation no.
2. Site Information	**URS Stretch length** **Distance form source** **Slope** Site surveyed from left/right Photographs taken Bed visibility Adverse conditions	**NGR upstream** **NGR downstream** **Solid geology code** **Drift geology code**
3. URS Stretch Engineering	**Cross profile** **Planform** **Level of Reinforcement**	
4. Channel Dimensions: (once only measurements)	**Location (GPS position / NGR / spot check)** *Channel Dimensions:* Channel water width Channel bank full width Channel water depth *Left /Right banks:* Bank top height Embanked height	**Distance from u/s point**
Spot check measurements (x10)	**GPS (NGR or Lat/Long) at each spot check location**	
5. Physical Attributes (1m transect)	*Left /Right banks:* Bank material **Bank protection** Marginal & bank features *River Channel:* Channel substrate Flow type Channel features	
6. Bank top Land use and Vegetation structure (10m transect)	*Left /Right banks:* Bank land use code (within 5m) Vegetation structure - Bank top (within 1m) Vegetation structure - Bank face	
7. Channel vegetation (macrophytes)	Vegetation types (**as % of transect)**	**Additional notes e.g. macrophyte species present** Channel choked with macrophytes?

Cumulative or ‘Sweep up’ measurements		
8.Bank profile & protection	*Left /Right banks:* (**as % of length)** Bank profile – natural/unmodified Bank profile – artificial Reinforcement - artificial Bank protection material	
9. Land use (within 50m corridor)		*Left /Right banks: (***as % cover)** Land use code (**incl. additional urban codes)** **Additional information from aerial mapping**
10. Artificial influences	Artificial features (bridge/weir/etc) Nuisance Species **(as frequency class)**	**Recent Management**
11. Extent of pollution	**Pollution indicators (as A/P/E)** **Pollution sources (as count)** **Water clarity**	
12. Habitat features	Physical habitat feature **(as count)** Flow type **(as % of length)**	
13. Special features	Tree features *Left /Right banks:* Tree distribution	
14. Ecological characteristics		Presence of species: Invertebrates (aquatic/ terrestrial) Mammals Amphibians / Reptiles Birds Fish Trees / plants

3.2.1.2 Rationale for choice of environmental research method

The URS method represents an integrated environmental assessment approach for urban rivers that provides the opportunity to sort river stretches by engineering type: a unique feature compared to other urban river methods described in section 2.2.4. The choice of the URS as the primary environmental methodology for this research project is further validated by several important reasons. Firstly, the URS has been adapted from a standard methodology developed for application on UK rivers and streams. As such it provides a geographically appropriate method with the scope to combine semi-quantitative and qualitative data about both natural and anthropogenic river habitat, enabling an integrated assessment of habitat:engineering interactions. Secondly, access to historic URS data allowed original London river data and indices to be compared to earlier findings, to validate the historic URS model and to test the capacity of the method to: (i) provide a simple tool to communicate the findings of the scientific assessment of urban river habitat condition to practitioners and stakeholders; (ii) support decision making for practitioners by discriminating between reaches e.g. to determine options for bio-physical river restoration works; and (iii) support regulators in targeting physical mitigation measures to meet policy requirements e.g. within the Water Framework Directive: River Basin Management Plans and Biodiversity Action Plans.

3.2.1.3 Advantages and limitations of the Urban River Survey method

The URS requires very little specialist equipment, field preparation, or laboratory analysis to generate research outputs. Yet the extensive semi-quantitative and qualitative data it provides describing geomorphological, biological and artificial (anthropogenic) characteristics of 500m stretches of river from a relatively rapid bank-top reconnaissance survey represent an important strength for this method. The URS therefore provided an information-rich and practical research methodology to meet the objectives of this thesis. Before undertaking data collection, the researcher attended the Environment Agency RHS training course in order to gain understanding of the similarities and differences between the two habitat survey methods and the principles underlying the URS approach. Although training is currently not essential for URS surveyors (the RHS and URS manuals provide detailed definitions and guidance), access to RHS training provided several advantages, such as additional confidence in habitat feature identification, accelerated familiarisation with the methodology and aided communication with the EA and other RHS surveyors.

As well as providing a unique integrated method of assessment, the strengths of the URS approach in combining scientific investigation with strong visual outputs that facilitate knowledge exchange, led to additional support from the EA (North and South Thames Areas) in developing the URS method as a knowledge exchange tool. This included practical in-field survey assistance in the survey catchments and parallel sampling of macro-invertebrates in the Mayes Brook, (reported in the Mayes Brook Catchment Restoration Strategy, Environment Agency, 2010a).

Recognised limitations of the URS method are primarily associated with the subjectivity of the data collection process. Data variability due to subjective interpretations of key features or percentage estimates can lead to margins of error when data are recorded by different surveyors, a weakness also recognized in the RHS methodology (Raven et al. 2000). Despite the in-depth training and accreditation process required for RHS suveyors, the variability in recorded data is recognized and accounted for within the interpretation of results (Murphy et al. 2008). Other aspects related to the interpretation of survey guidance and surveyor expectation regarding the details of habitat recorded in relation to specific project focal points came to light as the research developed (e.g. MSc Water Vole project; Gomes, MSc Thesis 2011) and through the URS training workshop.

In response to queries raised during peer review regarding the validity of comparing urban river data from different areas of Europe, it is first noted that land use pressures of urbanisation reproduce similar channel modifications and impacts on river form and function in different developed countries with similar biomes (Walsh et al. 2005). As the URS surveyed rivers are all located within the European Union they are also subject to the same requirements under the EU Water Framework Directive to achieve good ecological status, or potential (if classified as heavily modified). Therefore all of the pan-European URS data were considered to be suitable to for use in the validation and comparative analyses undertaken in support of this thesis.

3.2.2 Bio-physical data analysis

The URS survey data gathered on tributaries of the River Thames in Greater London were analysed and synthesised to meet four key objectives:

(i) to develop scientific knowledge of the bio-physical characteristics of London tributary rivers;

(ii) to validate the results of the historic ‘3 Rivers’ dataset (including the River Tame, West Midlands, River Emscher, Germany; and River Botic, Czech Republic);

(iii) to test the ability of the URS to compare bio-physical characteristics at the catchment and reach scales; and

(iv) to investigate the science knowledge transfer interface through communication of URS findings with practitioners and non-river experts.

To meet these objectives, three methods of data analysis were used to generate: (i) a set of aggregated indices describing the properties of stretches of urban river (Boitsidis et al. 2006); (ii) a thematic classification relating to the materials, physical habitat and vegetation structure of survey stretches (Davenport et al. 2004) and a combined score, the Stretch Habitat Quality Index (SHQI, Boitsidis and Gurnell, 2004); and (iii) a multivariate ordination of the aggregate indices using Principal Component Analysis (PCA) which define a series of environmental gradients. A simple URS Matrix describing the character and quality of these environmental gradients then allows interpretation of the engineering:habitat associations expressed by the Principal Components for each site surveyed (Gurnell et al. 2011). These three methods and outputs are described in further detail below.

3.2.2.1 URS Aggregated Indices

The natural and artificial environmental variables recorded by the URS field methodology, may be used to generate up to 50 synthetic or aggregate indices which describe the properties of the materials, physical habitat and vegetation structure of urban river stretches, as well as other observed urban pressures e.g. indicators of pollution and invasive species (Boitsidis et al. 2006, Table 3.3). For the purposes of this thesis, an automated calculations spreadsheet was created in MS Office Excel 2007 and developed throughout the research period to generate (i) the aggregate indices from the raw URS data, (ii) the classification and SHQI scores (each based upon the URS index calculations, Davenport et al. 2004); plus (iii) numeric outputs in a format suitable for populating an updated MS Office Access or web-based database.

The URS indices provide an opportunity to compare selected characteristics of stretches within and between urban catchments. The results of a comparison between London river URS aggregated indices for counts of habitat types and tree features (presented in section 4.2.2) formed the basis for further analysis through the thematic classifications and multivariate analyses as described in the following sections.

3.2.2.2 URS Classification method

Thematic classifications for Materials (bank and bed, natural and artificial); Physical Habitat (within the river channel and margins); and Vegetation Structure (riparian and aquatic vegetation), were developed by Davenport et al. (2004) using hierarchical cluster analysis to identify different typologies for urban river habitat characteristics. For each classification category, the discrete nature of the clusters which emerged from the historic URS data was tested using Kruskal-Wallis analyses. Full details of the method are provided by Davenport et al (2004) so only a brief description is provided here. Most importantly, this approach established the statistical significance of the differences between the emergent clusters or classes. The URS classification method was further developed by Boitsidis et al. (2006) to provide decision trees, defined by the key differentiating or discriminating indices. The URS decision trees allow users to assign individual stretches to each of the Materials, Physical Habitat and Vegetation Structure classes using threshold values for the key indices. Boitsidis et al (2006) also define individual class scores across the range of types within each class category for each surveyed stretch (reproduced in Table 3.4). By adding the individual class scores together, it is possible then to generate an overall score known as the ‘Stretch Habitat Quality Index’ (SHQI), representing a ‘high level’ indicator of habitat condition in relation to the stretch engineering (Boitsidis and Gurnell, 2004; Boitsidis et al. 2006).

For this research project, all surveyed stretches within the new London URS dataset, were classified by Materials, Physical Habitat and Vegetation Structure, the URS class scores were calculated and then combined to generate an integrated SHQI score. The SHQI scores for individual stretches (maximum range = 3 to 18), provide a broad indication of habitat condition and modification (Table 3.5), which may be described as ‘very good’ (SQHI score = 3 to 5) through to ‘very poor’ (SQHI score = 17 to 18). For example, a stretch score of 3 indicates a semi-natural channel with varied and active physical habitats and complex vegetation cover, particularly in the riparian zone, whereas a stretch score of 18 indicates a heavily reinforced channel with less than 3 habitat types and extensive algal cover.

Table 3.3 Urban river survey aggregated indices sorted by materials, physical habitat, vegetation structure and urban pressure. (Source: Boitsidis et al, 2006)

MATERIALS INDICES	**PHYSICAL HABITAT FEATURE INDICES**	**VEGETATION STRUCTURE INDICES**	**URBAN PRESSURE INDICES**
Bed Sediment Calibre Index (SEDCAL)[1]	Dominant Flow Types	Bank Vegetation Structure Index (BANKVEG)[1]	Count of Pollution Types
Proportion Immobile Substrate	Number of Flow Types	Average Channel Vegetation Cover	Count of Special Feature Occurrence[1]
Dominant Channel Substrate Type	Proportion of Pools	Count of Channel Vegetation Type	Count of Nuisance Species
Bank Sediment Calibre Index (BANKCAL)[1]	Proportion of Marginal (connected) Deadwater	Dominant Channel Vegetation Type	Extent of Nuisance Species
Proportion Immobile Bank Materials	Proportion of Glides	Count of Tree Features	Number of Input Pipes
Dominant Bank Material Type	Proportion of Riffles	Extent of Channel Shading	Number of Leach Points
Dominant Bank Material Protection Type	Proportion of Runs	Complexity Bank Face Structure	
Bank Protection Index (BANKPROT)[1]	Proportion of Ponds	Complexity Bank Top Structure	
Dominant Bank Protection Category	Proportion of stagnant (disconnected) Standing Water	Complexity Tree Cover	
Number of Bank Protection Types	Count of Vegetated Side Bars		
Proportion Biodegradable Bank Protection	Count of Unvegetated Side Bars		
Proportion Open Matrix Bank Protection	Count of Sand / Silt Deposits		
Proportion Solid Bank Protection	Count of Mid-channel Bars (veg & unvegetated)		
Proportion No Bank Protection	Count of Point Bars (veg & unvegetated)		
	Count of Habitat Types		
	Dominant Natural Bank Profile Type		
	Count of Natural Bank Profile Types		
	Proportion Natural Bank Profile		
	Dominant Artificial Bank Profile Type[1]		
	Count of Artificial Bank Profile Types[1]		
	Proportion Artificial Bank Profile		

[1] Indices not included in PCA underpinning the URS matrix

Table 3.4 URS Classification method and scores (Source: Boitsidis et al, 2006)

URS Classes: sorted by theme (abbreviation)	**Threshold values for discriminating class boundaries identified through cluster analysis**					
Materials	**Proportion immobile substrate (%)**	**Proportion bank protection (%)**	**BANKCAL**	**SEDCAL**	**Dominant protection type**	**Score**
Semi-natural Fine (SNF)	< 80	<= 10	>= 2.5			1
Semi-natural Coarse (SNC)	< 80	<= 10	< 2.5	< -1.5		1
Semi-natural Mixed (SNM)	< 80	<= 10	< 2.5	>= -1.5		2
Lightly Engineered (LE)	< 80	> 10, <= 70				2
Engineered (EN)	< 80	> 70			Open matrix	4
Moderately Engineered (ME)	< 80	> 70			Solid	4
Heavily Engineered (HE)	>= 80	>= 90				5
Physical	**Proportion artificial bank profiles (%)**	**Proportion natural bank profiles (%)**	**No. habitat types**			**Score**
Semi-natural Active (SNA)	<= 50	>= 90	> 7			1
Recovering (RC)		< 90, > 50				2
Semi-natural Stable (SNS)	<= 50	>= 90	<= 7			3
Uniform Active (UA)	> 50	<= 50	5+			4
Uniform Moderately active (UM)	> 50	<= 50	2 to 3			5
Uniform Stable (US)	> 50	<= 50	1 to 2			6
Vegetation	**Dominant vegetation type**	**Total tree score**	**Ave. BankVeg (BankFace)**	**Ave. BankVeg (BankTop)**		**Score**
Vegetated Moderate Complexity1 (VMC1)	Vegetated - other	<= 6	> 5	<= 4		1
Vegetated Moderate Complexity2 (VMC2)	Vegetated - other	<= 6		> 4		1
Vegetated High Trees (VHT)	Vegetated - other	> 6				2
Unvegetated High Complexity (UHC)	Unvegetated	> 6	> 6.5			3
Unvegetated Moderate Complexity (UMC)	Unvegetated	> 6	<= 6.5	>= 6		4
Vegetated Low Complexity (VLC)	Vegetated - other	<= 6	<= 5	<= 4		5
Unvegetated Low Complexity (ULC)	Unvegetated	<= 6 or				6
		> 6	<= 6.5	< 6		6
Algal Channels (ALG)	Vegetated - algae					7

Table 3.5 Stretch Habitat Quality Index (SHQI) values and associated materials, physical habitat and vegetation class categories (Adapted from Boitsidis et al. 2006)

SHQI values	**Category**	**Classes most likely to be associated with SHQI values**		
		Materials	**Physical Habitat**	**Vegetation**
3 - 5	Very good	SNC, SNF	SNA, RC, SNS	VMC1, VMC2, UHC, VHT
6 - 8	Good	SNC, LE	RC, SNS, UA, UM	VMC1, VMC2, UHC, VHT
9 - 11	Average	SNC,SNM, LE, ME	RC, UA, US, SNS	ULC, UHC, VMC2
12 - 13	Below average	SNC, LE, HE	UA, UM	ULC, UMC, ALG
14 - 16	Poor	HE, ME, EN	UM US, UA	ULC, UMC, VLC, ALG
17 - 18	Very poor	HE	US	ULC, ALG

As a simple measure of river habitat quality, the SHQI score can be used to communicate contrasts between individual stretches or across multiple catchments. The limited number of discriminating indices used within the URS Classification method may appear to be a gross simplification of the recorded detail of characteristics which represent the composite and dynamic engineering:habitat interface. However, the purpose of the URS classification and decision tree approach is to serve as a statistically validated filter to reduce the complexity of the data and to identify broadly different types of habitat and engineering within modified stretches at the meso-scale and as a basis for further investigation. The strengths and limits of the URS Classification method and the SQHI scores attained by the surveyed London river stretches are presented and discussed in Chapter 4 (section 4.4.1).

3.2.2.3 Principal Component Analysis and Urban River Survey Matrix

Principal component analysis (PCA) supports the simplification and interpretation of complex multivariate data sets containing large numbers of related variables. Application of PCA reduces the ‘dimensionality’ or complexity of multivariate data sets by identifying new independent gradients or components within the data set that explain a progressively diminishing proportion of variance within the data. Thus the greatest amount of variance expressed across the whole dataset is expressed by the first few PCs (Jolliffe, 1986). This multivariate analytical approach can be easily applied through the use of software packages containing the appropriate statistical tools. MS Excel compatible software XLSTAT (2010) is a user-friendly affordable package that includes PCA analytical functions and was therefore chosen for this research project.

As many of the original URS variables did not display a normal distribution or were comprised of integer or percentage data, the PCA was applied to a Spearman's Rank Correlation matrix of URS indices. This analysis was applied to 42 indices derived from the historic '3 Rivers' dataset to reveal two strong gradients of bio-physical habitat structure that could be associated with the style of channel engineering (Gurnell et al. 2007). More recently, Gurnell et al. (2011) have demonstrated that by excluding engineering modification indices (e.g. materials and levels of reinforcement) from the PCA and analysing only the environmental response indices, it is possible to identify four distinct environmental gradients within urban rivers, reflecting (i) the extent and diversity of depositional habitats, (ii) riparian and aquatic vegetation type and biomass, (iii) sediment calibre, and (iv) flow energy influences on environmental response to channel management.

Within this research project, PCA was applied to the combined '3 Rivers' and London Rivers datasets using XLSTAT (2010) software for the sub-set of indices indicated in Table 3.3 above. In order to communicate differences between reaches and potential trajectories of adjustment to changed conditions, it is possible to focus on the first two Principal Components (PC1 and PC2) which provide interpretable gradients when plotted on a two dimensional scatter graph. These two gradients describe transitions from heavily reinforced, habitat-poor channels to lightly or un-reinforced semi-natural channels with high habitat diversity; and from tree lined channels to channels with extensive aquatic vegetation, and form the basis of an easily visualised two-dimensional grid, the URS Matrix (Figure 3.2), defined by Gurnell et al. (2007). As new data are gathered for individual stretches, these can also be arranged along these environmental gradients and compared to the historic data in conjunction with additional stretch observations such as fixed point photographic data. The PCA results for the London tributary rivers are presented in Chapter 4 in relation to the historic data validation (section 4.3.1) and habitat quality comparisons at the reach and catchment scales (sections 4.4.2 and 4.5.4).

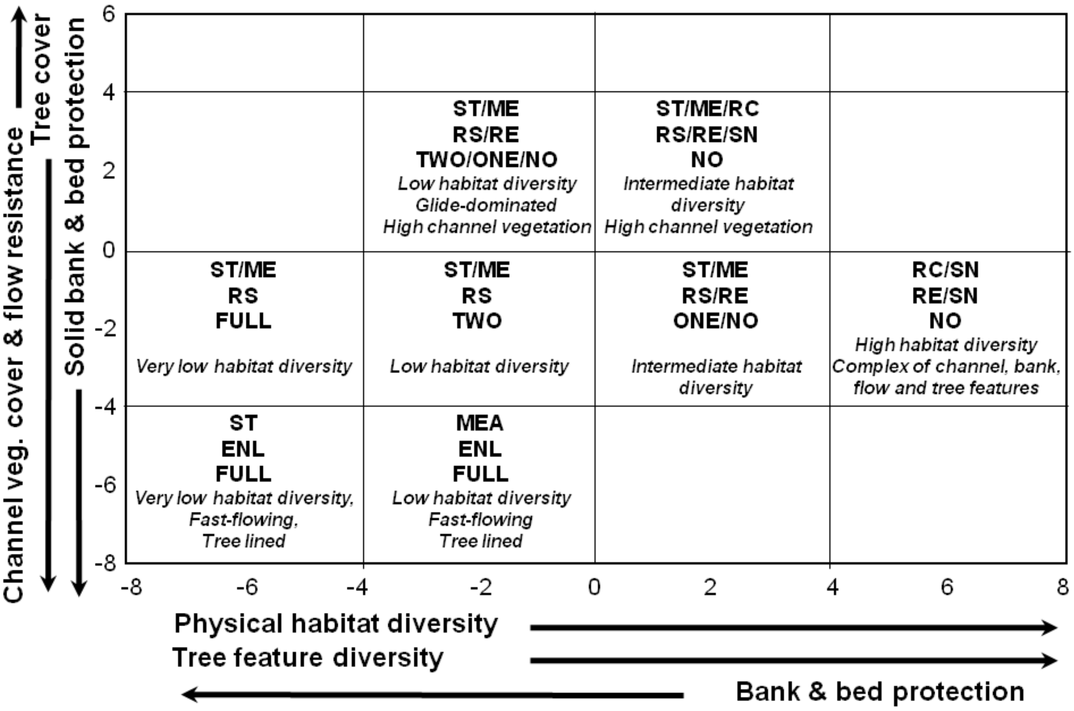


Figure 3.2 URS matrix describing the environmental gradients defined by the Principal Component Analysis of URS aggregate indices

3.2.3 Environmental study areas: Regional and local investigations

This section describes the techniques applied through the regional and local scale assessments of London river habitat quality using primary URS data and a regional scale analysis of secondary data relating to London river restoration practice.

3.2.3.1 Regional URS investigation: Thames tributaries within Greater London

While the selection of environmental survey locations would ideally be randomised, access limitations within the London tributary catchments determined that the surveyed catchments and stretches were selected through a combination of accessibility (often associated with the presence of nearby green infrastructure) and opportunity. Practical Health and Safety requirements for urban river field work to be carried out in pairs, meant that opportunities to visit accessible sites on London tributaries were often facilitated by pair working with other research postgraduates or practitioners interested in using the URS. Despite these limitations, an overview of the distribution of stretches across the Greater London area (Figure 3.3) confirms the geographical variety of locations surveyed as well as the distribution of stretches from upstream to downstream

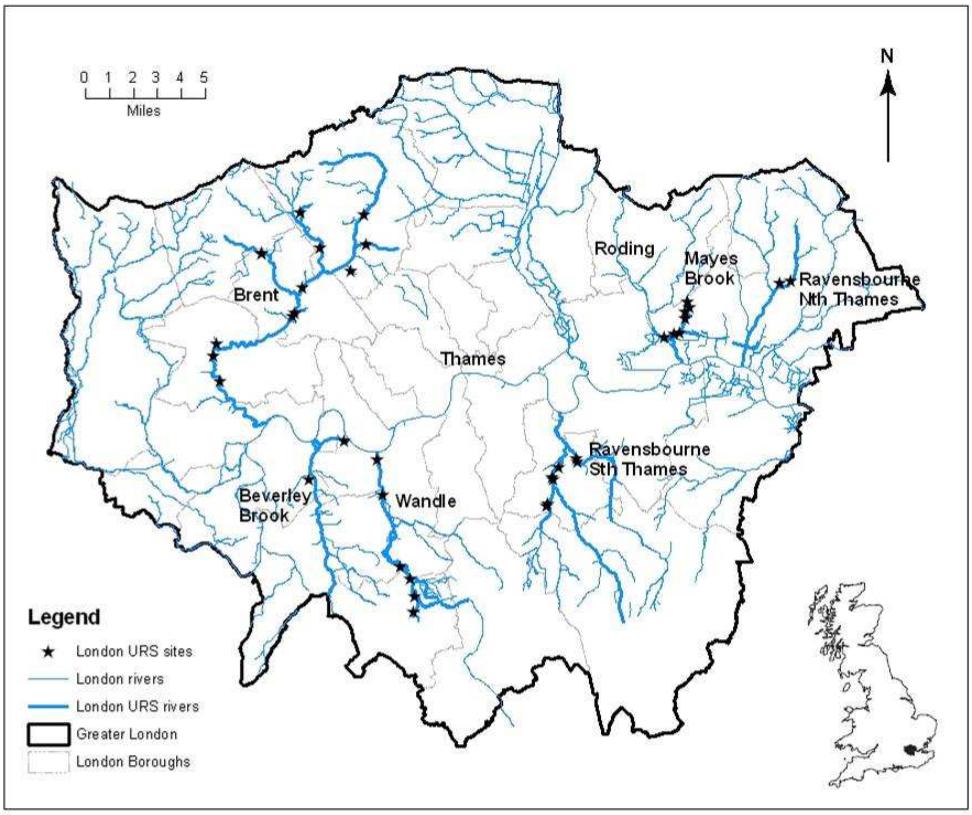


Figure 3.3 Map of URS study areas and survey sites in Greater London

within different catchments, resulting in a broadly representative sample of river types and conditions.

Throughout the environmental research period (2009-10), the URS field assessment method described above was used to collect data at 51 locations on seven tributaries of the Thames across the Greater London area both north and south of the river Thames (Table 3.6). Surveys undertaken in 2009 provided bio-physical urban river and riparian habitat information for 37 survey stretches which were analysed in relation to the historic findings and the URS Matrix (Gurnell et al. 2007). Additional sites surveyed within the River Lee catchment during 2010 are not included in this thesis due to time constraints and the influence of the Lee Navigation within that catchment.

In order to validate the URS model and enable interpretation of the regional results, the London URS data analyses were first compared with information from the (pre-2009) URS database obtained for three previously surveyed urban rivers in the West Midlands, UK (River Tame), Germany (River Emscher) and the Czech Republic (River Botic) known as the ‘3 Rivers’ dataset. The ‘*important and deep-seated associations*’ between engineered channel modifications and habitat qualities demonstrated by

Table 3.6 Table of river catchments and stretches surveyed in Greater London region 2009-10

River Catchment	**River(s)**	**No. stretches surveyed**
Brent	Brent	8
	Deans Brook	1
	Dollis Brook	1
	Silk Stream	1
	Clitterhouse Brook	1
	Mutton Brook	1
Beverley Brook	Beverley Brook	2
Ravensbourne (South Thames)	Ravensbourne	4
	Quaggy	2
	Pool	2
The Ravensbourne (North Thames)	The Ravensbourne	2
Roding	Mayes Brook	8
Wandle	Wandle	6
Lee[1]	Lee Navigation	5
	Turkey Brook	2
	Lee River	4
	Bow Creek	1
TOTAL		51

[1] Surveys from the Lee system recorded during 2010 were not included in data analysis due to time constraints

Gurnell et al. (2007) using the ‘3 Rivers’ dataset provide the basis for interpretations of the London PCA results via the URS Matrix (section 4.3.1).

3.2.3.2 Local URS investigation: reach to catchment scale comparisons

Following on from the regional URS interpretations, more detailed catchment and local scale investigations were carried out to compare the bio-physical habitat condition of adjacent reaches. Two pair-wise reach comparisons were carried out in the Brent and Ravensbourne catchments to investigate the differences between restored and unrestored reaches and between different restoration approaches. In each catchment, an adjacent unrestored reach was chosen to represent the pre-restoration condition of the restored study reach, therefore providing a proxy for before and after restoration (section 4.4.2). The Mayes Brook (a minor tributary of the river Roding in northeast London) provided a series of eight semi-continuous surveys of the unculverted reaches within the lower catchment. These data enabled a catchment-scale comparative analysis of habitat quality and URS Matrix analysis was used to identify those stretches which would benefit most from bio-physical remediation works (section 4.5.4).

Both restored sites on the Brent and Ravensbourne and the unrestored (pre-restoration) site in the Mayes Brook catchment, plus an additional historic restoration site on the Pool River, were used as case studies for the wider investigations into changes in restoration practices and the planning and management of urban river restoration in London. The case study sites are first introduced in this section and the integrated research focus for the case studies described further within section 3.4.

3.2.3.3 Local URS investigation of restoration practices

Since the 1990s, river restoration projects within London have improved over 22 km of river length (Environment Agency et al. 2009), during this time changes in restoration practice have reflected advancing river science knowledge described in Chapter 2. Four case study sites, located on tributaries of the Thames in Greater London, were selected to investigate the outcomes of changes in approaches to river restoration since the 1990s as well as the potential role of the URS in planning and appraising urban river restoration projects. The case study sites, located on the Mayes Brook at Mayesbrook Park (pre-restoration); the River Ravensbourne at Ladywell Fields (restored 2008); the River Brent at Tockyngton Park (restored 2004); and the River Pool at Bell Green Gas Works (restored 1994) provide a snapshot of different approaches to urban river restoration implemented over the last 15 years (Figure 3.3, Table 3.7). The pre-restoration case study at Mayesbrook Park (restored during 2011), offered an opportunity to observe the role of river habitat assessment during the pre-construction consultation and planning stages.

Analysis of the URS data obtained for the four case study sites is presented in Chapter 4 (section 4.6) in relation to a time line of urban river restoration practices. The main research focus for the post-restoration sites is on the physical differences in urban river restoration style in terms of the level and type of engineering involved; and the intended geomorphologic improvements in comparison with the outcomes: observed as post-restoration channel adjustments or responses.

Table 3.7 Case studies restoration time line and overview of the engineering works associated with each of the selected case study sites

River	**Pool (Ravensbourne tributary)**	**Brent**	**Ravensbourne**	**Mayes Brook (Roding tributary)**
Location (Borough)	Bell Green Gas Works (Lewisham)	Tokyngton Park (Brent)	Ladywell Fields (Lewisham)	Mayesbrook Park (Barking & Dagenham)
Restoration timeline	1990s =======================>>>> 2010s			
Planning started	c.1990	c. 1999	c. 2004	c. 2006
Restoration completion	1994	2004	2008	2012
Restoration character	New channel created; river 'daylighted'; new sinuous channel created	Channel re-meandered; light reinforcement concealed within banks	New weir bypass channel created with floodplain landscaping; without reinforcement	New channel and wetland areas created; floodplain landscaping; without reinforcement
Main motivations for restoration[1]	Habitat; Opportunistic; Development Gain	Habitat; Community demand; Opportunistic; Flood defence; Development Gain	Habitat; Fisheries; Community demand; Landscape	Habitat; Flood defence; Fisheries; Community demand

[1] As specified within LRAP / RRC spreadsheet

It was expected that the level and type of engineering applied would strongly reflect the physical constraints associated with each site, the restoration paradigms prevalent at the time of scheme implementation (Clifford, 2007) and the lapsed time available for the river to self adjust. As described above, for the restored sites on the Brent and Ravensbourne, it was possible to survey a nearby unrestored river stretch as an indication of their pre-restoration condition. However, for the River Pool site, the pre-restored river was completely culverted underground, and adjacent reaches modified at a later date so no stretch indicative of its pre-restoration state was available. In all cases, URS data are used to assess the current bio-physical condition and ecological benefits achieved through the historic rehabilitation works.

The results of the case study URS assessments are interpreted in relation to the restoration and management history of each site, in comparison with the control reaches and the broader regional URS results for Greater London (sections 4.4 and 4.5). Further discussion of the advantages and limitations of using an integrated case study approach in relation to the interdisciplinary aspects of this research project is provided in section 3.4.3.

3.2.3.4 Regional investigation of river restoration data for Greater London

Additional regional data analyses provided insights into the historic context for urban river restoration practice within London since the 1980s. These involved an investigation of secondary data recorded by river restoration practitioners and held by the River Restoration Centre (RRC), an independent UK-based organisation established in 1998 that operates as an advisory service and resource base for practitioners (www.therrc.co.uk/). Based at the University of Cranfield in Hertfordshire, the RRC maintain strong links with river research and are closely associated with the Environment Agency both nationally and within Thames region. As part of their role in supporting river restoration practitioners, the RRC maintain a substantial database of information about restoration projects across the UK. Individual case study data are publically available and can be accessed via an interactive GIS map online at www.therrc.co.uk/. For research purposes, the full database is available for members to query on request.

The RRC web resource is also linked to the London Rivers Action Plan (LRAP, www.therrc.co.uk/lrap/), an additional regional GIS database launched in 2008 and developed in partnership with the EA, Natural England, London Wildlife Trust, Thames River Restoration Trust, World Wildlife Fund-UK and the Greater London Authority. The LRAP provides a knowledge exchange and networking resource for the Greater London practitioner community. Managed jointly by the EA and RRC, the LRAP database includes regularly updated details of completed and proposed river restoration projects across the London area.

Data provided by the RRC, including a total of 285 (RRC) and 195 (LRAP) records for river restoration projects within the Greater London area completed during 1988-2011, were analysed to provide information relating to their planning and delivery. As some records were duplicated between the databases, it was not viable to combine the two sets of data. However, similarities in content enabled a range of comparative and complementary analyses with a degree of validation for some investigations. Data fields within the RRC and LRAP databases, indicated in Table 3.8, reveal the breadth of

Table 3.8 Data fields within River Restoration Centre (RRC) and London Rivers Action Plan (LRAP) databases (order modified to enable content comparison)

RRC Database fields	**LRAP Database fields**
Contact	Main contact
Conversation contact	Main contact address
Design Engineer contact	Main contact email add
	Main contact telephone number
Project	Project name
National Grid Ref	NGR
Background	Site background
Status	Existing status (2010 update)
	Updated status if applicable
Location	
County	
Agency region	
Main river	Catchment
	Tributary
Length	Project length (m)
Year start	
Year end	Date ended - year
Total Cost	Cost total
	% Cost (Planning/Prep/Pre-monitoring)
	% Cost (Works)
	% Cost (Post-project appraisal/monitoring)
Main funders	Main funding organisation
	Funding secured?
Non-funding partners	Non-funding partners
Other funders	
Objectives	Project objectives
Main motivation	Main motivations
	Key aspirations - Climate Change?
	Key Aspirations - Flood Risk Management?
	Key Aspirations - Urban Regeneration?
	Key Aspirations - Access & Recreation?
	Key Aspirations - Biodiversity Enhancement?
Comments / outcome	Comments (lessons, things to note, successful?)
Audit?	
Documentation?	RRC comments documentation references
References?	
job catchment floodplain soils	
job catchment flow type	
job catchment geology 1 general	
job catchment river bed gradient	
job catchment river substrate	
job catchment river type	
job catchment site designation	
job catchment studies	
job catchment type	
job catchment water quality constraint 1 Y/N	
job catchment water quality constraint 2 detail	
job cumecs 1_100	
job cumecs bankfull	
job cumecs normal low	

content overall including project objectives and motivations (plus LRAP project aspirations) and funding sources. Although gaps within each database presented limitations to some analyses, overall the LRAP and RRC data provided valuable insights and supporting information to both the environmental and social science research components within the thesis and a background context for the London case study projects. The findings are reported in Chapter 6 (section.6.1).

3.2.4 Development of URS method

The results of the London river data analysis (Chapter 4) demonstrate how the URS outputs can be used to illustrate summary information about the bio-physical character of urban rivers. Simple research output tools that can communicate scientific knowledge about river condition at a range of scales and to a wide variety of stakeholders are of interest to practitioners and organisations such as the Environment Agency (Charles, 2007). In an urban context, stakeholder engagement and knowledge exchange are especially important in relation to achieving and sustaining successful outcomes (Boon, 1998, Clifford, 2007) and meeting policy targets for the rehabilitation of urban rivers e.g. via the London Rivers Action Plan (Webb, 2009 pers. comm.) and the Water Framework Directive (Entec, 2008). The need for improved communication of river science is highlighted in several policy documents and discourses (introduced in section 3.5), reflecting a number of social issues, including:

(i) *public concern about the increase in flooding incidents*: the 2005 Defra report ‘Making Space for Water’ outlines the benefits of slowing the passage of water through urban catchments, increasing water storage capacity, reconnecting rivers with their floodplains and increasing wetland habitats (Defra, 2005);

(ii) *private development by riparian landowners:* a ‘Section 106 Agreement’ (Town and Country Planning Act, HMSO 1990) represents a funding mechanism within UK planning obligations often used to finance mitigation works, offsetting the impacts of development through the restoration of adjacent river reaches;

(iii) *urban regeneration of riparian land or open public spaces:* the London Rivers Action Plan highlights opportunities to restore the habitat potential of urban river reaches within public spaces (Environment Agency et al. 2009);

(iv) *strategic biodiversity-based strategies to encompass multiple conservation objectives across a wider geographic areas:* the Lawton Report: *Making Space*

> *for Nature* (Lawton, et al. 2010) highlights the need to redirect conservation efforts away from a single species or habitat focus towards integrated approaches, e.g. the Thames and Tributaries Integrated Biodiversity Delivery Area.

The development of the URS method in association with the Environment Agency during this project provided an opportunity to investigate the communication of scientific information about the bio-physical quality of urban river reaches with practitioners and (non-)technical professionals involved in river restoration planning. Knowledge gained through the application of the environmental, social and interdisciplinary research methods in this thesis has been used to inform the development of the URS method and outputs in the context of planning and managing urban river restorations (i) for ‘blue skies’ research purposes, i.e. to enhance knowledge and understanding of urban river assessment; (ii) as a knowledge exchange tool to communicate river science with stakeholders and (iii) for strategic pre- and post-restoration assessment. A summary of the specific URS development objectives is provided in Table 3.9.

Due to time and size constraints, examples of feed back responses from all trials (MSc students and URS workshop) are provided in Appendix B however specific points of relevance to the URS method development and results are integrated within the Chapters 4 and 8.

Table 3.9 Summary of aspirations for the development of the URS at the start of the research project

Objective	**Aim**	**Actions**
A. Develop river science knowledge exchange capability of URS	A.1 Improve URS form layout and guidance	(i) simplify layout and improve legibility; (ii) add basic guidance on how to identify key indicator features (in line with RHS)
	A.2 update URS Manual	Bring URS manual up to date to reflect changes applied to form and guidance
B. Develop accessibility of URS to users	B.1 Automate calculation of indices	Develop Excel spreadsheet with user input panels and automated outputs for indices and classification results.
	B.2 Produce GIS Map output:	Use London URS results to illustrate catchment-to-reach scale habitat quality maps
	B.3 Identify areas of user need e.g. in relation to site selection; post project appraisal; stakeholder engagement etc	Interaction with case study partners and other practitioners to gauge needs and discuss potential role for URS
C. Field test updated URS method with users	C.1 Test usability and gather feedback	(i) URS student trials: R. Wandle 2008; R. Lee 2010; Water vole study 2011 (ii) Case study fieldwork with survey partners (iii) URS practitioner workshop 2011
	C.2 Trial URS methods (Indices and Classification) for London urban river restoration objectives	(i) working with the EA / London Biodiversity Partnership; (ii) Mayes Brook case study monitoring strategy development.
D. Review URS Scoring	D.1 Reduce URS data recording to minimum for calculations	Use URS indices and classification calculations to identify essential and non-essential data inputs
	D.2 Develop indices that provide indicators of bio-physical dynamism and diversity	(i) hydrological and geomorphologic dynamism i.e. identify processes which indicate function e.g. scour / deposition; (ii) plant biodiversity (macrophytes and riparian communities) i.e. features which illustrate turnover in communities and vegetation diversity;
	D.3 Use URS database to investigate data analysis methodologies	devise measures using standard deviation or variance within spot check data
E Develop URS training format	E.1 Develop a URS training workshop format suitable for a wide range of practitioners and non-expert interest groups	URS trial workshop: delivered 23rd June 2011 to 24 participants from public and voluntary sector organisations

3.3 Ecosystem Services Assessment

Building on the introduction to the development of the Ecosystem Approach within the UK and applications of ecosystem services valuation (section 2.4), this section describes how the UK Environment Agency method (developed by Everard. 2009) was applied to the main case study (reported in section 4.7).

3.3.1 Rationale and objectives for using Ecosystem Services Assessment

The Ecosystem Services Assessment (ESA) was used as a secondary method of urban river assessment within this thesis in order to compare different types of interdisciplinary approach and their contributions to urban river restoration planning. The main objectives of the application of ESA to the main case study were to gain insights into this interdisciplinary approach and how scientific knowledge is becoming integrated into environmental governance.

Since 2009, the Environment Agency has built a portfolio of ESA case studies for a range of aquatic environments, most of which have been in rural locations (section 2.4). In response to interest from project partners (the Environment Agency) and in line with the thesis research objectives, an ESA was undertaken for the Mayesbrook Park Restoration Project through a partnership between the EA and QMUL. Led by Everard and supported by Gurnell, the Mayesbrook ESA was based upon the methodology developed by Everard (2009) and adapted for an urban setting. As the first UK urban river ESA, the project delivered a prototype report and baseline from which to refine the ESA method for urban river catchments.

3.3.2 Advantages and limitation of ESA method and valuation techniques

As a method of environmental valuation, the ESA approach involves many assumptions and presents many limitations due to the unknown nature and lack of effective valuation tools for many ecological services, especially those relating to the cultural benefits provided by urban river restorations. However, this method also provides highly significant opportunities to progress the discourses around sustainable development, to bridge its three disciplines (social, environmental, economic) through novel approaches, and to engage non-environmental professionals and other stakeholders in discussion around long term sustainability issues and environmental valuation.

The ESA approach links the monetisation of ecosystem services with a range of market valuation approaches (section 2.4). Following the methods described within ‘The Green Book: Appraisal and Evaluation in Central Government’ (HM Treasury, 2003), the ‘lifetime’ benefits for a restoration scheme can also be estimated over a specified number of years. For example, within the Mayesbrook ESA a conservative discount rate of 3.5% was applied for the first 30 years, falling to 3% for 31-40 years. These rates may be used to calculate Net Present Value (NVP) for the desired number of years, to reflect the falling rate of the pound, using annual factors provided in The Green Book (HM Treasury, 2003).

Application of the ESA methodology is based upon the assumption that the derived economic values carry no absolute meaning but enable the calculation of *marginal values*. Thus allowing changes in ecosystem services as well as the scale of change: from the baseline condition immediately prior to intervention works to the post-restoration altered state, to be reflected as positive or negative tendencies (Everard et al. 2011). The transparency of the ESA method is maintained by the inclusion of calculations and workings, which represent an essential component of all ESA reports. This approach avoids the risk of double counting and allows individual cases to be critiqued and refined as new knowledge becomes available for monetisation of individual services. Where valuation is not possible (e.g. method not yet determined) or feasible this is clearly stated, in line with recommendations made by The Economics of Ecosystems and Biodiversity Report (TEEB, 2010a).

The use of this simplified approach aims to avoid giving the impression of prescriptive economic accuracy within the process, thus allowing for the high level of embedded uncertainties associated with the majority of service calculations associated with social, economic (e.g. market), and environmental variability (Everard and Moggridge, 2011). One of the main challenges of ESA is to give an indicative evaluation whilst avoiding the impression that the assessment confers an absolute cost:benefit outcome. To this end is useful to regard the purpose of an ESA as a conservative estimate of potential benefit and a knowledge exchange tool rather than a precise economic tool.

3.3.3 ESA investigation of Mayesbrook Park Restoration Project

Production of the ESA for the Mayes Brook case study incorporated a number of stages. Following a site visit and review of the proposed restoration works with steering group members, a meeting was held to work through the Millennium Ecosystem Assessment table of ecosystem service categories (provisioning; regulating; cultural; and supporting services, MA, 2005a, Table 2.17). A detailed list of services relevant to river and wetland environments, identified through the preceding Environment Agency ESA case studies, was taken as the starting point and developed in relation to the an urban river setting. The resulting table of services was gradually populated with information specific to the Mayesbrook Park restoration.

Following Everard (2009) the assessment applied at Mayes Brook took a pragmatic approach to the evaluation of the potential changes in ecosystem services that might accrue from the proposed river and park restoration scheme. For each identified service, clear descriptions of the method of quantification and source reference material were provided to enable transparency and avoid double counting; associated assumptions were clearly stated and predicted changes in service provision linked to likely increases or decreases in capital or revenue values. Where economic benefits were attributed to ecosystem services at Mayesbrook Park, these were derived from a range of real and surrogate market values or peer-reviewed publications of related studies. As with any ESA, many of these calculations were based upon the best available information at the time of writing and clearly stated assumptions. Following a series of review consultations, the final calculations were agreed between the lead author and EA environmental economists.

The populated table of results including calculations and comments regarding assumptions and adjustments was included as an Annex in the final Mayesbrook Park Restoration ESA report, with summary information provided in the main document text. Where gaps in knowledge were indicated, evidence of relevant research in that area and recommendations for future research development were highlighted. An abridgement of the final report is provided in section 4.7, with the full table of calculations as shown in the final report provided in Appendix D.

3.4 Case Study Approach

The definition of interdisciplinary approaches defined in Chapter 1 describes these as operating within the spaces between disciplines, integrating perspectives and constructing common models of working through dialogue between disciplines (Petts et al. 2005, Bruce et al. 2004; Ramadier, 2004). In the context of this thesis, the use of a case study approach has provided a vehicle for the interdisciplinary integration of the environmental and social components of this research project, drawn together through the environmental and social assessments and research methods described in this chapter. Section 3.4.1 begins with a description of the interdisciplinary role and broad aims of the case study approach to investigate the environmental, social and socio-environmental components of urban river restoration. Next, section 3.4.2 defines the specific objectives for the case study investigations. The advantages and limitations of using a case study approach are detailed in section 3.4.3.

3.4.1 The interdisciplinary role of the case studies

Case studies provide researchers with unique opportunities to observe closely and record ‘live’ activities and naturally occurring interactions within and between environmental and social situations. As such, case study observations may also be used to complement other qualitative or quantitative research techniques (Flick et al. 2004) and to build up a ‘thick’ description of the subject material provided by the analysis of qualitative source data representing multiple perspectives (Sayer, 1992).

Within this thesis, the chosen case studies facilitated and united two contrasting yet complementary strands of research. The first is concerned with the post-project appraisal of the environmental outcomes and different historic approaches to urban river restoration, while the second relates to the planning and delivery of new urban river restorations. Following the brief introduction to the restoration history of the London case studies in section 3.2.3.4, this section provides an overview of their wider role in this investigation of interdisciplinary approaches to urban river assessment, planning and management.

As described previously, the case studies were chosen to represent an historic sequence of urban river restoration dating back to 1994 (Table 3.7). The case study sites each characterise different approaches to restoration practice and offered the opportunity to compare restoration and management practices with post-project recovery condition of the study sites using the URS assessment method. A complementary set of aims focusing in upon the planning and management of urban river restoration projects, and the role of the URS assessment method in options appraisal, were also facilitated through the case studies. Their investigation involved the use of a range of qualitative methods indicated in Table 3.10 as described in the following sections.

Table 3.10 Overall aims for case study approach in relation to urban river planning and management and contributing methods

Overall aims	Case study comparisons	Discourse analysis	Observation	Interviews	Other
1. Gain an understanding of the planning and implementation of an urban river restoration through one major case study	✓	✓	✓	✓	
2. Gain an understanding of the governance and partnership structures and interactions between the institutions and individuals engaged in urban river restoration projects	✓		✓	✓	
3. Observe and interpret the different roles of each organisation in terms of (i) their objectives in relation to the project (ii) the contributions and resourcing that they can bring	✓		✓	✓	RRC/ LRAP data analysis
4. Identify the tensions that arise between different organisations and their contrasting objectives and contributions	✓		✓	✓	
5. Explore the extent to which it is possible to achieve multiple objectives for environmentally and socially focused organisations.	✓		✓	✓	
6. Explore the suitability of integrated environmental assessments i.e. URS and ESA as decision making tools for multidisciplinary groups involved in urban river restoration but with different objectives or agendas.	✓		✓	✓	URS / ESA

3.4.2 Objectives for case study investigations

To gain an understanding of the planning and delivery processes involved in an active restoration project, the primary case study at Mayesbrook Park was chosen in consultation with biodiversity officers in the EA North Thames Area from a shortlist of projects due to be completed within the research period. The Mayes Brook project was selected because the proposed restoration involved the greatest length of channel and a complex mix of partners including public, private and voluntary sector institutions. The project also represented a high profile case which carried substantial expectations with regard to the integrated restoration works and climate change adaptation outcomes.

The Mayes Brook case study provided an opportunity for detailed investigation of the planning, resourcing and implementation of the restoration of the brook. The specific objectives of the case study investigation were:

(i) to identify the main drivers responsible for initiating and steering the urban river project, as well as attracting the involvement of different partners;

(ii) to identify the main objectives associated with the project for each of the partners;

(iii) to discover what resources each partner organisation was able to contribute to the project and by what mechanisms / processes;

(iv) to discover what the project needed to deliver for each partner organisation to fulfil resourcing conditions;

(v) to identify what (if any) challenges, conflicts or constraints arose during the planning and delivery stages for each organisation;

(vi) to link the stakeholder objectives with the ecosystem services provided by the urban river (pre- and post-restoration condition);

(vii) to evaluate the role of assessment and decision making tools, specifically a reach-scale (i.e. URS) habitat survey, in providing effective support for decision making by multi disciplinary partnerships involved in urban river restoration.

In addition to the primary case study, the combined secondary restoration case studies presented a temporal series of urban river restorations which provided valuable opportunities to explore:

(i) differences in the governance approaches taken to restore urban rivers;

(ii) differences in problem solving strategies employed through urban river restoration;

(iii) perceptions of post-restoration river adjustment over time;

(iv) differences in post-restoration management.

In particular, the recently completed QUERCUS restoration project at Ladywell Fields provided some valuable comparative research material through interviews with key members of the steering group. Although the unique circumstances of each project necessitated the cautious use of project comparisons, advantages included the opportunity to identify potential commonalities and the presentation of generic characteristics.

3.4.3 Advantages and limitations of the case study approach

From both environmental and social disciplinary perspectives, the overriding value of a case study is the opportunity to gain first hand experience of ‘real time’ interactive processes. For social science observations of group processes, an important advantage comes with the opportunity to build trust within a group and thus gain access to material and information which otherwise would not be available or divulged; and to observe at close hand the processes and interactions occurring between the different actors and wider networks (Donmoyer, 2000).

For environmental, social or interdisciplinary objectives, the risk of generalising and translating the findings between case studies indiscriminately needs to be managed transparently. The complexity and variability of natural environments and social interactions presents problems for both quantitative and qualitative science as predictive empirical formulae or theoretical inferences may only be applicable to the setting where they were derived (Shaw, 1983; Gomm et al. 2000). While the value of generalising through case studies is recognised by Donmoyer (2000), Gomm et al. (2000) also highlight questions that need to be addressed in relation to delivering appropriate generalisations in relation to theoretical as well as empirical generalisations, drawn from case studies. In the case of the former, the variability of external factors means that theoretical generalisations should only be based upon *‘a set of identified relationships among variables that are universal, in the sense of occurring everywhere that specified conditions hold’* (Gomm et al. 2000 p.103). This may be associated with a degree of probability, given that one of the primary universal assumptions may be that of heterogeneity between different cases or within target populations.

The presence of complexity, both within and beyond case studies is reflected not only through environmental variables or the social interactions between individual actors (Donmoyer, 2000) for example, within a partnership but also in relation to the integration of the core environmental and social components of a case study project. Complexity therefore also confounds the ability to generalise through research findings and undermines the certainty of generalities which do not fit with individual idiosyncrasies. There are also problems in the generation of stereotypes which may arise as inflexible interpretations of individuals or organisation types. In the light of these potential pitfalls, the research outcomes for the case studies (and ethnographic analyses) are discussed in Chapter 7, mindful of the premise that findings '*can suggest possibilities, but never dictate action*' (Donmoyer, 2000 p.51).

The importance of clear boundaries for case studies is also highlighted by Gomm et al. (2000). In this research project and particularly in relation to the primary case study at Mayesbrook Park, the author recognised the substantial risk of the research role becoming less focused, and 'fuzzy edged' through the ambiguity of performing dual roles as an external and internal researcher. In relation to the latter role, the involvement of the author included (i) the scientific investigation and reporting of the biophysical condition of the unrestored river thus contributing to the restoration project's baseline data; and (ii) the collation of working group inputs during the development of the Mayes Brook monitoring strategy using the prototype PRAGMO methodology in partnership with the RRC. A brief review of the challenges arising through ethnographic research approaches in relation to participant observation is provided in section 3.6.3.

3.5 Documentary Discourse Analysis

Documentary discourse analysis has the potential to support understanding of short and longer term decision making in management contexts (May, 2001). In the context of this thesis documentary research provided an opportunity to place the observed data in the context of the policy and regulatory drivers currently influencing urban river planning and management decisions. Analysis of policy documents associated with the development of urban rivers (or 'blue spaces') and green infrastructure was undertaken to gain an understanding of the drivers and context for urban river restoration in London. In particular, the influence and responses of key stakeholder institutions to the recently introduced Water Framework Directive and Thames River Basin Management Plan are reviewed in the context of urban river planning and management strategies (section 5.1). An overview of the documentary evidence reviewed is provided in Table 3.11.

While the main research period for this project covered 2009-10, more recent publications e.g. UK National Ecosystem Assessment (UK NEA, 2011a, 2011b) are also considered where applicable in terms of future directions. The overall aims of the documentary discourse analysis were

(i) to identify and interpret the influence of the main environmental policy drivers upon urban river restoration.

(ii) to identify where bridges and divides arise between disciplinary areas and their potential to impact upon urban river management.

Table 3.11 Overview of documentary evidence reviewed through discourse analysis

Year	**Policy Document**	Water	Biodiversity	Flooding	Climate	Planning	Regeneration
1992	EC Habitats Directive (92/43/EEC)		✓				
1994	Biodiversity UK Action Plan (HMSO, 1994)		✓				
2000	The Countryside and Rights of Way Act (HMSO, 2000)		✓				
	EU Water Framework Directive (2000/60/EC)	✓	✓				
	A Strategy for parks and green spaces - Public summary. (LBBD, 2004a)		✓			✓	✓
2005	Making Space for Water (Defra, 2005)	✓		✓			
2008	England Biodiversity Strategy - Climate Change Adaptation Principles, (Defra, 2008a)		✓		✓		
	Adapting to climate change in England: A Framework for Action (Defra, 2008b)			✓	✓	✓	
	Barking and Dagenham Landscape Framework Plan (LBBD 2008)					✓	✓
	London Rivers Action Plan (Environment Agency et al. 2009)	✓	✓				
2009	Thames River Basin Management Plan (Environment Agency, 2009a)	✓	✓				
2010	Planning Policy Statement (PPS) 25: Development and flood risk, (DCLG, 2010)			✓			
	The London Plan (GLA, 2011)					✓	✓

The analysis examines the breadth of policy relating to urban river restoration and extent to which (inter-)disciplinary approaches are embedded within the existing governance discourses. As such, it considers whether they provide effective practical tools to support the integrated planning and delivery of urban river restoration projects and the sustainable management of urban rivers. The results of the discourse analysis are presented in Chapter 5 and provide the background for Chapters 6 and 7, which examine urban river restoration practice: firstly from a historic perspective through analysis of London-wide RRC and LRAP data; and secondly, through desk studies and observations of the case studies.

3.6 Ethnographic analyses

3.6.1 Rationale for the choice of social research methods

The emerging models of integrative river assessment and management described in Chapter 2 reflect the introduction of policies promoting ecosystem-focused approaches and the need to deliver sustainable benefits, especially within urban contexts. A corresponding need to integrate socio-environmental objectives in urban river assessment, restoration planning and management strategies, provides the rationale for an extension of methodological approaches to encompass social science and qualitative analytical techniques within this thesis.

To complement the environmental science methods described in earlier sections, a selection of ethnographic social research techniques were also employed to provide insights into the role of socio-environmental components and social processes involved for multi-disciplinary partnerships engaged in the planning and delivery of urban river restoration projects. An ethnographic approach provides a flexible *'iterative-inductive'* methodology which involves *'sustained contact with human agents within the context of their daily lives (and cultures), watching what happens, listening to what is said and asking questions'* (O'Reilly, 2009). Ethnography draws upon a range of methods including interviews and participant observation, and allows the design of the study to evolve through analysis of field notes and coding (i.e. labelling and sorting data by key themes), following the principles of grounded theory whereby the observations of real situations and data analysis lead to the construction or interpretation of theories rather than the reverse (O'Reilly, 2009).

These methods were selected to investigate (i) the presence and role of interdisciplinary approaches within urban environmental governance, partnership and decision making in relation to contemporary management challenges for London rivers; and (ii) how partners' perceptions and interpretations of urban rivers and restoration planning and management affect the ways in which integrated understandings and outcomes develop.

To provide evidence for the core arguments within the thesis, the explicit aims of the ethnographic research components were to:

(i) Identify the planning and implementation processes involved in an urban river restoration project through the primary case study (at Mayesbrook Park);

(ii) Identify the governance and partnership structures, relationships and interactions between the institutions and actors engaged in the primary and secondary case studies;

(iii) Observe and interpret the different roles of institutions and individuals in terms of their objectives in relation to the project, and the financial and other resources or services that they can contribute;

(iv) Identify the tensions that arise between different organisations and their contrasting objectives and practices;

(v) Explore the extent to which it is possible to achieve multiple objectives for environmentally and socially focused organisations;

(vi) Explore the suitability of interdisciplinary assessment tools (such as the URS or Ecosystem Services Assessment) for knowledge exchange among multidisciplinary groups and stakeholders with different objectives or perspectives involved in urban river restoration decision making.

To meet these aims, a combination of methodologies (Table 3.12) enabled the validation of findings through different types of evidence, expanded understanding by capturing different aspects of the research issues and reduced the risk of overemphasis of a single research approach (Flick, 2004, p.180).

3.6.2 Ethnographic methods

The use of ethnographic methods within this project provided key insights into the planning processes involved in the (pre-construction) delivery stages of the primary case study: the Mayesbrook Park Restoration Project, and the wider context of urban river restoration within London. Qualitative data collected during 2009-11, included a combination of participant observations at steering and sub-group meetings, public consultation and launch events, plus interviews with key actors involved in urban river

Table 3.12 Outline of qualitative methods used to meet the research objectives

Method	**Subject(s)**
Partnership Observations	Mayesbrook Project steering group and other meeting observations, included: (i) recording and reviewing decision making processes within steering and other planning groups; (ii) reporting on and reviewing the responses to *regional scale* results of the URS data analyses for the London rivers; and (iii) reporting on and reviewing the responses to *local scale* results of the URS data analyses for the Mayes Brook catchment.
Actor Interviews	A total of 20 semi-structured interviews undertaken with key individuals involved in urban river restoration planning and delivery within Greater London: including in the Mayesbrook Park case study (13) and other projects (7). Interview guide questions are provided in Appendix C
Documentary analysis	Policy documents and grey literature generated through the urban river restoration case studies (e.g. minutes, formal agreements, master plans etc).

Table 3.13 Summary of meetings attended and interviews undertaken during the research period

Type of meeting	**Number attended**
MBRP meetings	
- Steering Group	12
- Steering Group / Special meeting	6
- Monitoring Strategy sub-group	2
- Events	4
- LBBD Internal board meeting	1
- Local Residents meeting	1
- Ecosystem Services Assessment planning	2
GLA Priority Parks / Help a London Park (HeLP) meetings	2
Brent Catchment Partnership meeting	1
Integrated Biodiversity Development Area meetings	2
Additional URS meetings:	
- URS development with Environment Agency	6
- URS development with River Restoration Centre / Thames Rivers Restoration Trust	2

restoration in London. A diary of all meetings attended was maintained throughout the research period and is summarised in Table 3.13.

These primary data formed the basis for the observational and reflexive ethnographic analysis undertaken in this thesis. The following sections introduce each method and describe the data collection and analysis techniques undertaken for the ethnographic investigations.

3.2.2.1 Participant observation of partnership

As a research method, participant observation of group processes brings the benefits of gaining insights at close proximity to observed practices, and also through the flexibility of this research strategy (Luders, 2004). The rationale behind the use of observation methods in this project was to capture primary data for the main case study at the steering group level: to record (i) partnership interactions and planning processes involved in project implementation, and (ii) the information needs and types of knowledge exchanged between partners. The degree to which the planning partnership was able to deliver multiple integrated benefits linked to environmental and social objectives was of primary interest. The observation process enabled the investigation of specific aspects of the case study project governance including:

(i) the priorities for the various organisations and levels of integration of different objectives;

(ii) the resources that organisations were able to contribute to the project and associated conditions; and

(iii) partners' expectations of the planning process and project outcomes.

In practice, the partnership observations involved aspects that were both passive (silent note taking); and participatory (engaging in and contributing to discussion when invited). For example, the researcher was able to feed back the results of the commissioned URS assessment report: the Mayes Brook Catchment Restoration Strategy (Environment Agency, 2010a); and contribute to the collation of information to be included in the post- restoration monitoring strategy. Challenges associated with this method highlighted by Luders (2004) include the maintenance of distance or detachment from the subject alongside personal involvement. This aspect, and the risks of over attachment or 'over-rapport' (O'Reilly, 2009) were recognised by the researcher from an early stage and throughout the observation period as sometimes conflicting roles demanded different levels of involvement and detachment. These were managed by a combination of openness (reiterating role in relation to partners where appropriate) and reflexive monitoring: observing reactions and responses of self and others in relation to the engagement processes associated with different activities.

A core component of the participatory research role was concerned with how introduced scientific information, (e.g. the URS report), was received and interpreted by the steering group partners. Information shared with the steering group, included regional scale URS data for Greater London as well as the more detailed Mayes Brook survey results. By participating in the knowledge building and sharing processes it was possible to observe and evaluate the ways in which the URS outputs contributed to information exchange across the multi-disciplinary group and their subsequent contributions to decision making processes at different stages of planning and implementation (i.e. restoration delivery, future monitoring and management options).

3.2.2.1 Actor interviews

> *'An ethnograpic interview is like an in-depth conversation that takes place within the context of reciprocal relationships, established over time, based on familiarity and trust.'* (O'Reilly, 2009, p.125)

Of the four main interview techniques employed by social scientists (Structured; Semi-structured; Focused; Group) the most appropriate method to meet the requirements of this thesis was identified as the semi-structured interview. This approach uses a range of questions to steer the interview session but allows interviewees to extend answers beyond these by inviting them to expand on key issues (May, 2001).

The primary focus for the interview data collection was the Mayesbrook case study. However, additional interviews with actors involved in the Ravensbourne and Brent case studies and other London river restoration projects, provided a temporal and spatial context for the Mayesbrook data. The specific objectives listed in section 3.6.1, are relevant to each of the observation and interview data analyses, with the latter capturing directly the motivations and experiences of each partner organisation as expressed by the individual actors. Attention was paid to ensuring coverage across all sectors in the design of the interview programme, which included representatives from: the public sector: regional / local authorities and non-departmental public bodies (QUANGO) e.g. the EA; third sector: river trusts; civil society / local stakeholders and private sector organisations (Table 3.14). The semi-structured interviews were recorded (with interviewees consent) during informal sessions lasting approximately 60-90 minutes. Interviews were held during working hours in a variety of locations convenient to the interviewee. These included cafés close to or at places of work or near to the restored river site, with the specific aim of creating a relaxed atmosphere so that the informality and rapport (developed through contact during more formal steering group or other meetings) would allow for reflexivity and space for discussion of issues around the research themes.

The interviews were steered by a series of guide questions (provided in Appendix C) were organised into five broad groupings including:

A. Interviewee profile
B. Partnership role in planning and delivery of restoration project
C. Facilitation and tools for knowledge exchange
D. Environmental assessment tools enquiry
E. Integrated project experience

An important function of the interview guide questions was to gather information regarding organisational perspectives and objectives, including different requirements for measures of ‘success’ in relation to objectives and resource contributions (group B). Further questions were developed to identify key information needs and information accessibility (groups C and D), and included questions relating to the perception and relevance of the URS and Ecosystem Services Assessment (ESA) to different organisations. The final questions (group E) provided the opportunity for interviewees to reflect upon their own experiences of the urban river restoration project in terms of the integration of environmental and social targets, plus their overall impressions of working within an ‘interdisciplinary partnership’.

A total of 21 interviews were recorded, these were all transcribed by the author and coded thematically on the ‘hard copy’ paper transcripts and electronically within nVivo v.9 software. The emerging themes were subsequently regrouped and analysed further to identify the idiosyncratic or universal qualities within each. A detailed description of the ethnographic data analysis is provided in the next section and the results of the interview analysis presented in Chapter 7.

Table 3.14 Interviewees sorted by sector and organisation

Organisation / Body	**Position**	**Role**
i. Public Sector: Local / Regional Government		
LB Barking and Dagenham	Senior Park Development Officer	Mayesbrook project, Lead project manager
LB Lewisham	European Projects Manager Project Manager	QUERCUS project manager (finance) QUERCUS project manager (delivery)
GLA	Environment Programme Support Officer Environment Programme Officer	Mayesbrook project partner / sponsor Priority Parks / Mayesbrook project
ii. Public Sector: QUANGO		
Natural England	Recreation, Access and Quality Greenspace Delivery Leader Climate Change Adaptation and Green Infrastructure Advisor External Funding Delivery Leader	Mayesbrook project partner (engagement / access) Mayesbrook project partner (climate change / urban greening) Mayesbrook project partner (external funding)
Environment Agency	Conservation Team Leader / Technical Specialist Conservation Officer Biodiversity Team Leader Environmental Monitoring (Analysis and Reporting) Team Leader	Mayesbrook project, Lead technical partner Mayesbrook project, Lead technical partner QUERCUS project, Lead technical partner Brent Restoration, Lead technical partner
Design for London (DfL)	Urban Designer	Mayesbrook project partner (urban design)
CABE	Senior Sustainable Design Advisor	QUERCUS project
iii. Private Sector		
Quartet Design	Senior Landscape Architecture Consultant	Mayesbrook project consultant (landscape)
Royal Sun Alliance (Insurance)	Corporate Responsibility Manager	Mayesbrook project sponsor
Thames Water	Environmental Protection Team Manager	'Misconnections' project leader
iv. Third Sector: Charities / Trusts		
Thames Rivers Restoration Trust	Director	Mayesbrook project partner
London Wildlife Trust	East London Area Manager, People and Wildlife	Mayesbrook project partner (engagement/ environmental education)
Wandle Trust	Director	Wandle projects manager
v. Civil Society: Local Stakeholders		
Local residents groups	Nature Conservation Officer / Park User Group member	QUERCUS project partner

3.6.3 Ethnographic data analysis

The observation and interview data recorded for the Mayes Brook (primary) case study were used to generate a 'map' of the associations between institutions based upon their roles within the steering group to facilitate interpretation of the roles of key partners, their relationships and the dynamics observed (Figure 7.3, section 7.2.3). Data recorded for the secondary case studies and through additional meetings and interviews were also used to build a picture of current urban river restoration practices within London.

The ethnographic data, including observation notes taken during meetings and recorded interview transcripts, were analysed using thematic coding. The data were coded using a combination of manual and electronic coding techniques (applied through nVivo v.9 software) which allowed the data to be 're-contextualised' and interpreted through emerging themes (Bazeley, 2007). In order to meet the research aims and objectives listed in Table 3.10 preliminary thematic codes were first identified based upon the interview guide questions. Further emerging coding themes were then systematically identified through analytical reading and coding processes in reflection of issues raised by interviewees. Six preliminary coding categories were identified: 1. Objectives; 2. Governance; 3. Decision Making; 4. Resourcing; 5. Challenges; 6. Positive Outcomes (further details of the coding sub-themes are provided in section 7.1). Data coding within the nVivo software facilitated the task of sorting by key themes, revealing the rich variety of subthemes within the data and emerging categories and concepts (Figure 3.4). This process enabled key attributes and a set of secondary themes to be identified and reviewed (Table 3.15) in relation to interdisciplinary approaches to urban river planning and management.

The first set of themes described in Table 3.15 (Group I) derived mainly from the interview guide questions, represent relatively tangible attributes of environmental and project management processes relating to objectives or motivations, time, space and knowledge. Group II represent more a conceptual group of themes relating to complexity, dynamism and connectivity. The results of the coding analysis and interpretation of emerging themes in relation to the research aims to investigate partnership delivery, interdisciplinary approaches and management challenges for London urban rivers are presented in Chapter 7.

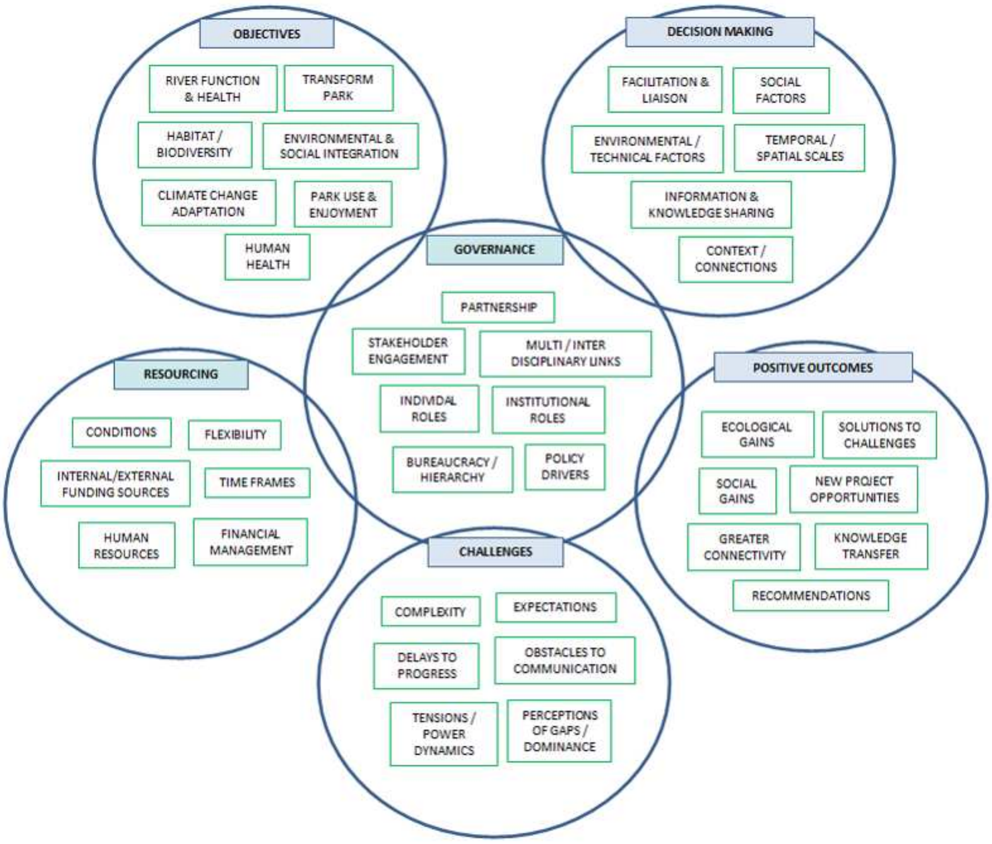


Figure 3.4 Mapping emerging themes revealed by coding field data

Table 3.15 Summary of the emerging themes and main attributes in relation to urban river restoration

Key Themes	**Main attributes**
GROUP I	
Integration	Integrating / balancing environmental and social objectives; Individual / organisational: cultures, motivations, interests (agendas);
Time scales	Definitions of time as cycles and frames; Synchronicity; Flexibility / Rigidity; How do partners / partnership model affect time management?
Spatial scales	Spatial connectivity and environmental and social perceptions of space and restoring urban river; Relating hierarchical environmental spatial scales to human spatial geography;
Knowledge	Exchange and knowledge gaps: assessment pre- and post-project appraisals; Expert and experiential ('lay') knowledge
GROUP II	
Complexity	Variability of environmental and human processes and systems; Information management; Generalisation vs complexity; Managing boundaries to contain and focus, whilst maintaining permeability and wider connections.
Dynamism	Environmental / physical dynamism and (un)predictability; Relationships and dynamics within partnerships relating to resourcing issues – financial and human; Fluidity of interdisciplinarity
Connectivity	Facilitation; bridges; flexibility; 'wicked' solutions; Permeability, Capacity recognition and prioritizing;

3.7 Conclusions of methodology

The combination of the science-based environmental and social research methods focused around the urban river regional and local scale studies together provide the evidence base for the investigations into the challenges for urban river assessment, restoration planning and management in the context of London that follow. The methods chosen reflect the range and nature of the (inter)disciplinary subject material and begin to suggest the level and extent of information and translation needs of non-river experts and stakeholders involved in urban river restoration and management.

In order to synthesise the results of the qualitative and quantitative investigations described in this chapter, a conceptualisation of the ways in which interdisciplinary approaches are generated led to a consideration of hierarchical approaches and 'wicked' problem solving.

3.7.1 Hierarchical approaches to interdisciplinary investigations and 'wicked' problem solving for urban rivers

As demonstrated within this chapter, the environmental and social methods described each adopt a hierarchical approach to considering spatial scales of environmental and social interactions and management (Table 3.16).

Table 3.16 Summary of the relevant scales for each of the research methods applied in this project plus relevance to supporting practitioners in achieving WFD compliance

METHOD	Local scale	Catchment scale	Regional scale	WFD relevance
Urban River Survey	✓	✓	✓	✓
Ecosystem Services Assessment	✓	-	-	✓
Case Study Approach	✓	-	-	✓
Documentary Discourse Analysis	✓	-	✓	-
Participant Observation	✓	✓	-	✓
Interviews	✓	✓	✓	✓

The choice of research methods was considered in terms of their relevance to urban river management at a range of scales appropriate to supporting river condition as well as the delivery of environmental policy objectives and particularly the Water Framework Directive. The synthesis of results in Chapter 9 considers the use of matrices in exploring the interdisciplinary associations between the environmental and social components of integrated research and for gaining an overview of interrelated qualities of the different disciplinary perspectives.

3.7.2 Critique of overall investigation methodology

The strengths and limitations of each method selected for this thesis and presented within the sections above highlight several advantages and challenges experienced in gathering and analysing both environmental and social data. For the environmentally focused methods, previous experience of the researcher gained through BSc and MSc environmental and aquatic research provided valuable knowledge of several of the methodological limitations and potential pitfalls of field surveying, desk study and quantitative data analyses. Throughout the research period it was however also recognised that environmental research is also a social practice (Sayer, 1992) and that within this interdisciplinary project new reflexive techniques would also be called for.

By adopting an interdisciplinary approach, the application of less familiar qualitative research approaches provided the researcher with a rich learning experience (and at times a steep learning curve) not only in relation to the social methods, but also in working out the best way to integrate the environmental and social elements within the thesis itself. In this context, throughout the research process an overarching aim of the social research components of this project has been to apply a reflexive process: to maintain awareness of the subjective position of the author in relation to the interpretation of the subject material (Alvesson and Skoldberg, 2000). To this end the analysis of the research material does not aim to establish the ‘truth’ of the material studies, but rather an interpretation of the observed material based upon the academic and professional experience of the researcher.

As a contributor to the main case study (scientific information base and monitoring strategy development) the different relationships and rapport generated with the steering group partners and practitioners led to a developing sense of vested interest in the project and its outcomes. Furthermore, the visibility of the contributing role played within the group in conjunction with the sense of familiarity generated through the interviewing process built rapport and increased openness from interviewees, providing a rich foundation for the ethnographic research component (O'Reilly, 2009). On reflection, the sense of being in a privileged and unique position through the doctoral research role, also heightened the author's sense of wanting to deliver high quality and valued outputs that would serve not only the thesis research objectives but also contribute to the legacy of the case study project itself.

The juxtaposition of the environmental and social research approaches, which provided equally valid semi-quantitative, positivist environmental science research methods alongside qualitative, constructionist and interpretivist, social science research methods, provided a valuable opportunity to compare and contrast these two perspectives in relation to the presence or absence of interdisciplinary approaches in urban river restoration. These contrasting perspectives each contribute throughout the thesis at relevant points as the author endeavoured to draw upon the full breadth of information available and make connections between urban river ecological and governance aims and outcomes.

Straying between the application and study of interdisciplinary approaches raised many conceptual questions e.g. in relation to socio-environmental conceptual integration and complexity, as explored through the literature review (section 2.3.4). As Sayer (1992) describes, the anomalies that exist between different conceptual approaches (e.g. environmental and social perspectives) may require a '*reconstruction of the network of sense-relations linking and forming concepts, rather like changing the wiring of a complex but faulty circuit*' (Sayer, 1992, p. 81). While the traditional disciplinary 'circuits' are not intrinsically 'faulty', they can however benefit through the creation of new conceptual connections, as many interdisciplinary insights have already demonstrated. It is within this context that this thesis endeavour to gain new insights and knowledge to benefit urban river environmental research and practices.

Recommendations for potential developments for the environmental and interdisciplinary methods applied in relation to the URS indices and ESA valuation methods are suggested in section 9.4.

Chapter 4: Results I – Urban River Survey

4.1 Introduction

This chapter presents the findings of Urban River Survey (URS) assessments of 37 stretches within Greater London. Section 4.2 describes the broad engineering and some selected biophysical habitat characteristics of London urban rivers identified from the URS surveys and compares these with URS data previously acquired for three other urbanised rivers: the Tame, UK; Boitic, Czech Republic; and Emscher, Germany and referred to as the ‘historic URS data set’. Section 4.3 is concerned with a Principal Components Analysis of habitat characteristics derived from URS data and the URS matrix that results from the PCA. It explores the applicability of the matrix to London rivers in comparison with the historic data set, focussing particularly upon the interpretability of the first two principal components (PCs) as environmental gradients for characterising contrasts between London river stretches.

The distribution of the London river stretches with respect to the first two PCs is then used to investigate their habitat condition, the legacy of their engineering histories and their responses to restoration interventions. Firstly, differences between adjacent river stretches with and without restoration are explored (section 4.4). Secondly, contrasts in the plotting positions of stretches within a catchment with respect to the first two PCs are investigated using all accessible stretches of the Mayes Brook, a minor tributary of the River Roding in East London (section 4.5). Thirdly, the plotting positions of four case study examples are explored as an example of a chronological sequence of restored urban river stretches and a sequence of outcomes of different restoration strategies (section 4.6).

Section 4.7 considers the influence of an ecosystem services policy focus upon urban river restoration initiatives and the application of a different kind of integrated assessment for urban rivers: the ecosystem services assessment (ESA). The section closes with a review of the process and outcomes of an ESA for the main case study: the Mayes Brook restoration in Mayesbrook Park, East London. Throughout this chapter the results of the assessment methods presented are considered in relation to research questions stated in section 2.5.2 (see Box 4.1) and the role of integrated approaches in communicating science beyond specialist disciplinary constraints in the context of urban river restoration.

The final section (4.8) provides concluding comments on the findings of the urban river assessments reported within this chapter.

Box 4.1 Research Questions (section 2.5.2)

- To what extent can ecologically successful and cost-effective river environment improvements be achieved through combined socio-environmental approaches to urban river restoration?

- To what extent are current environmental governance models and multidisciplinary partnerships able to deliver benefits for urban river environments and enhanced ecosystem services through urban river restoration projects?

- To what extent can integrated anthropo-environmental assessments of urban rivers (such as URS and ESA) provide tools to share knowledge and support decision-making for urban river restoration projects and support the delivery of environmental policy objectives?

- To what extent are existing environmental information resource bases and knowledge exchange processes providing support to multi-organisational partnerships in planning and delivering integrated socio-environmental projects?

4.2 Engineering and habitat features of London rivers revealed by the Urban River Survey: a comparison with the historic URS data set.

Urban rivers have been transformed by long histories of human modification and their effective management must take account of many different disciplinary interests (Downs and Gregory, 2004). The Urban River Survey (URS) is unique in the way it combines assessment of river channel engineering with naturally occurring bio-physical habitat features (section 3.2.1). Each surveyed stretch is defined by a single engineering type (i.e. combination of planform, cross section, and level of reinforcement types). These characteristics therefore provide the context in which habitat condition and ecological response to engineering modifications may be derived from the recorded data. The following comparisons of engineering characteristics (section 4.2.1) and two aggregate habitat indices (section 4.2.2) within the London and historic data sets, illustrate how URS indicators can provide a useful means of constructing generalisations and comparisons concerning the biophysical status of urban rivers.

4.2.1 Engineering types

The engineering character of the London river surveys were first investigated in comparison with the historic URS data set. A comparison of the components of the engineering type (i.e. planform, cross profile, reinforcement types) as percentage frequencies (Figure 4.1) immediately reveals several similarities and differences. Overall, the data indicate an engineering history for all surveyed urban rivers dominated by planform straightening and cross profile re-sectioning (historic data), and enlargement (London data). Differences in levels of reinforcement between the two data sets indicate a higher proportion of London river channels with one or two banks reinforced in comparison with the predominantly unreinforced character of the historic data set. Two reinforcement types (bed only, bed and one bank only) were not observed on any of the urban rivers surveyed.

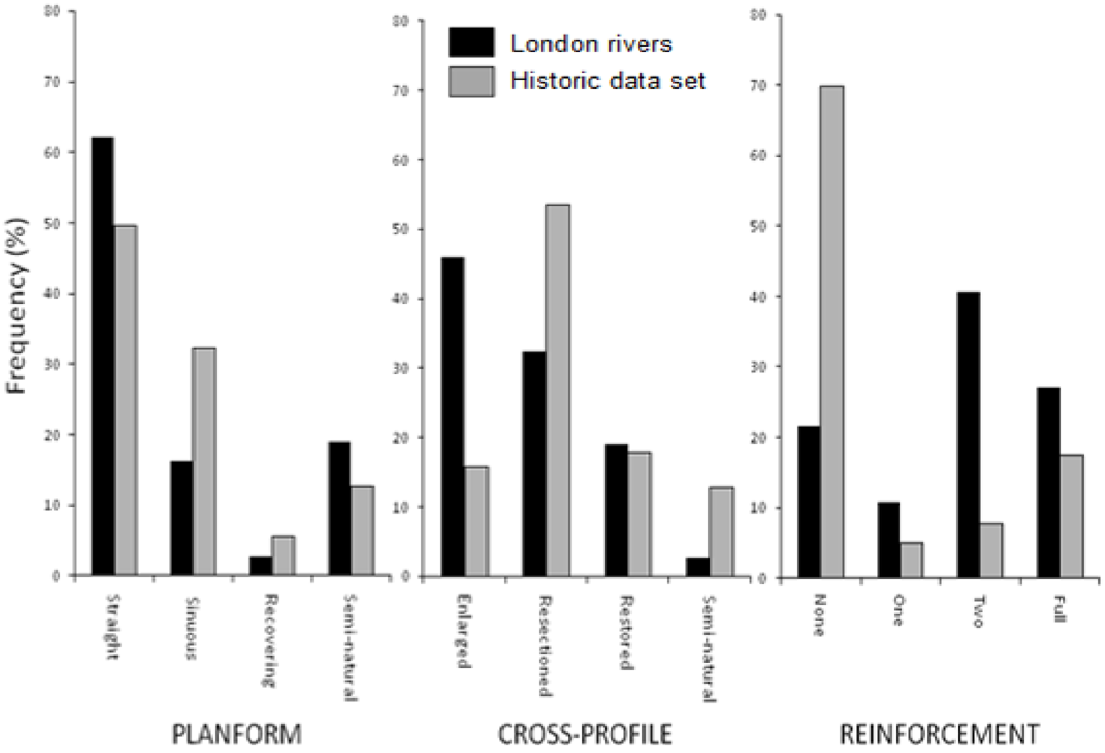


Figure 4.1 Bar charts comparing the percentage frequency of planform, cross profile and reinforcement types of the surveyed London rivers (2009) and the historic data set

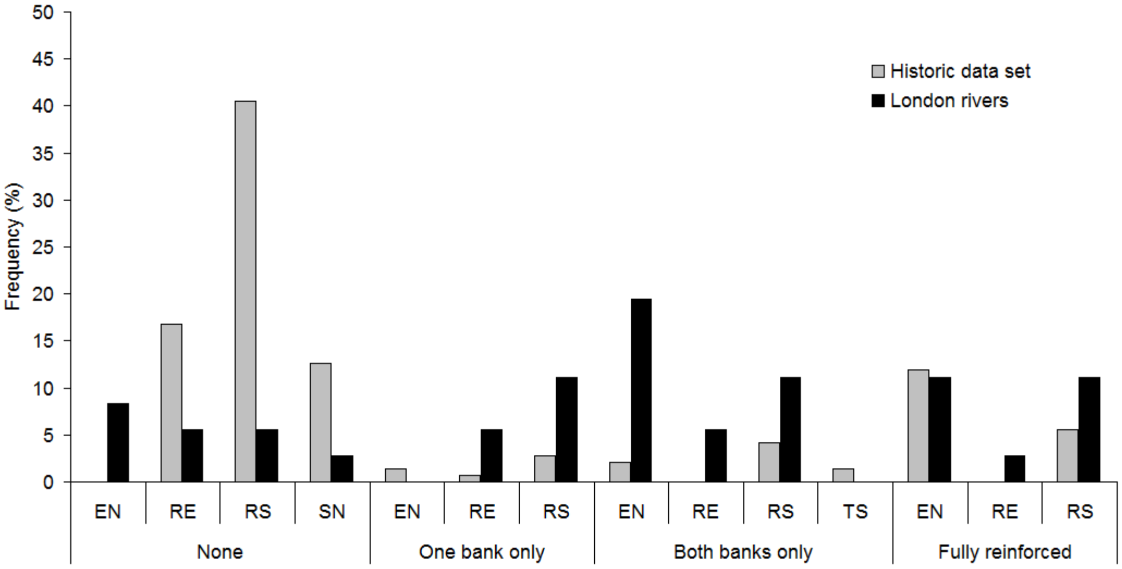


Figure 4.2 Bar chart showing the percentage frequencies of combinations of reinforcement and cross profile types found on surveyed stretches in the historic and London data sets (Cross-profile codes: CL= Cleaned; EN= Enlarged; RE = Restored; RS = Re-sectioned; SN = Semi natural; TS = Two stage).

The differences in engineering types found within the London rivers data suggest regional variations in engineering history or management responses to local conditions and warrant further investigation. The London data show higher proportions of straightened stretches with enlarged cross-profiles and bank and bed reinforcement compared to the historic data where engineered sinuous planforms, semi-natural and re-sectioned cross-profiles, and un-reinforced stretches dominate (Figure 4.1). These results provide an indication of the relatively higher level of engineering modification, particularly channel reinforcement, amongst the London stretches. The way in which these engineering characteristics tend to occur together on the same stretches is emphasised when cross-profile and reinforcement data are displayed together (Figure 4.2). Here the high frequencies of re-sectioned and un-reinforced channels found in the historic data series contrast strongly with the London data, which are dominated by enlarged and re-sectioned channels with one bank, both banks or full reinforcement. These engineering data provide several insights into the character of the London river channels and the history of their management. The high levels of reinforced, enlarged and re-sectioned channels reflect a history of industrial use and flood risk management within highly urbanised catchments (section 2.3.1).

4.2.2 Habitat features

The calculation of a range of aggregate environmental indices from the URS data (section 3.2.2) allows comparison of different biophysical properties of surveyed stretches; and an assessment of how these properties are interrelated and reflect the stretch engineering type. Two example aggregate indices (Count of Tree Features and Number of In-channel Habitats) illustrate their usefulness in investigating similarities and differences in habitat condition between the London and historic datasets (Table 4.1, Figures 4.3 and 4.4).

Table 4.1 Summary statistics for two aggregate habitat indices

	Count of Tree features		**Number of in-channel Habitats**	
	London data	**Historic data**	**London data**	**Historic data**
Mean	4.27	2.94	8.97	4.24
Mode	5	0	10	3
Max	10	10	17	14

4.2.2.1 Tree Features

The bar chart (Figure 4.3) illustrating ‘Count of Tree Features’ (including channel shading, overhanging boughs, exposed bankside roots, underwater roots, fallen trees and coarse woody debris) shows that the two data series cover the same numerical range up to a maximum of 10 tree features, but with contrasting distributions. The historic data are heavily skewed by a high frequency of stretches with 0, 1 or 2 tree features producing a mode of 0 and average of 2.94 tree features. In contrast, the London data are more normally distributed with a mode of 5 and average of 4.27 tree features. The higher counts of tree features on the London stretches concur with field observations of many stretches with well-developed riparian vegetation, particularly deciduous trees and related tree features indicating minimal riparian vegetation management.

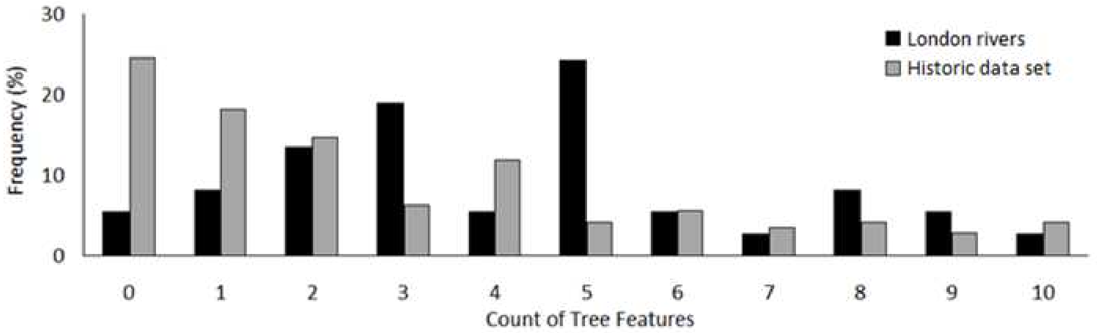


Figure 4.3 Bar chart showing percentage frequencies for Count of Tree Features

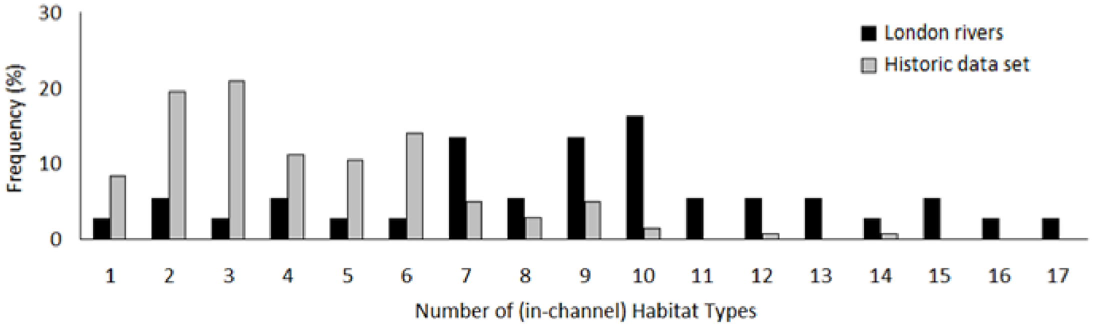


Figure 4.4 Bar chart showing percentage frequencies for Number of (in channel) Habitat types

4.2.2.2 In-Channel Habitat Types

Figure 4.4 shows the frequency distributions of ‘Number of In-Channel Habitat Types’ (including geomorphological features such as vegetated and un-vegetated bars, sand deposits and flow types such as glides, riffles). The London dataset reveals a maximum of 17 observed in-channel habitat types recorded at one stretch (2.7%), whereas the historic dataset indicates a maximum of 14 habitat types (at one stretch, 0.7%). Overall the relatively higher frequencies of in-channel habitat types within the London stretches are reflected in larger measures of central tendency (Table 4.1) suggesting a higher in-channel habitat diversity.

These findings are unexpected when considered in relation to the higher levels of bank reinforcement observed in the London dataset (Figure 4.1). However, the widespread use of wooden toe boarding as reinforcement and the low levels of channel maintenance observed in the field at several stretches may partly explain the clear signs of recovery from engineering intervention indicated by the development of diverse habitat features in the surveyed London stretches.

4.3 Validation of Environmental Gradients identified through Multivariate Analysis of URS aggregate indices

This section investigates the degree to which the results of a principal component analysis (PCA) applied to the historic data set (Gurnell et al. 2007) persist when new data gathered on stretches of London rivers are included in the analysis.

The original PCA (Gurnell et al. 2007) was conducted on 43 aggregate indices derived from URS surveys of 143 stretches within the historic data set. These indices described properties of the natural and artificial (reinforcement) materials, physical habitat and aquatic and riparian vegetation within the stretches. Ordination was applied with the aim of reducing this complex multivariate data set into a few independent, interpretable gradients that would allow simple visualisations of the data and comparisons between stretches and groups of stretches.

Because the aggregate indices comprised both integer and percentage measures, the PCA was conducted on a Spearman’s rank correlation matrix rather than the more usual product moment correlation matrix. The first two PCs accounted for 40% of the variation in the data set and described interpretable environmental gradients. The first (PC1) described a gradient from high to low levels of reinforcement and low to high diversity of physical habitats (e.g. increasing numbers of channel bed form types, flow types, natural bank profile types, tree features and increasing bank vegetation complexity). PC2 described a gradient from tree-lined channels with a high proportion of solid bank protection (e.g. concrete, brick, laid stone or sheet piling) to channels with little solid protection and a high cover of in-channel vegetation, including emergent and rooted submerged macrophytes. When the stretches were plotted on a scatter graph with respect to these two PCs, they displayed an interpretable pattern that reflected changing combinations of stretch planform, cross profile, level of reinforcement and biophysical structure (habitat types and diversity, aquatic and riparian vegetation) and underpinned a simple science communication tool that is called the URS matrix (Gurnell et al. 2007).

However, the arched pattern displayed by the stretches in the scatter plot could be criticized since arching can occur as an artifact of the analysis rather than a genuine reflection of environmental structure within the data. To investigate whether the stretch pattern underpinning the URS matrix was a genuine reflection of environmental gradients in the data, Gurnell et al. (2011) reanalysed the dataset, excluding all indices describing reinforcement or other engineering-related properties from the analysis. This reanalysis did not yield arching in the distribution of stretches with respect to the first two PCs; supported the underlying association of biophysical properties of the stretches with stretch engineering; and identified four interpretable environmental gradients in the data, relating to sediment supply and retention, extent and diversity of in-channel vegetation and riparian trees; bed and bank sediment calibre; and flow type energy and complexity. Although this reanalysis may be more statistically rigorous, it is too complex to act as a simple communication tool. Detailed comparison of the outcomes of the two analyses reveals no noticeable difference in their representation of the structure of the dataset or the relative locations of individual stretches within the space defined by the first two or four PCs. Therefore, the structure revealed by the first PCA and summarized within the URS matrix appears to be a genuine reflection of the interaction between engineering and other biophysical properties of the surveyed stretches and will form the basis of the exploration and interpretation of the London river dataset in this section.

The main objective of this research component is therefore to assess whether the gradients and potential applications of the PCA ordination and related URS matrix are transferable to the London rivers dataset.

4.3.1 Application of PCA to the combined historic and London URS data sets

As described in section 3.2.2.3, a PCA was performed on a Spearman’s rank correlation matrix derived from observations of 43 aggregate indices for the combined historic and London data sets (180 urban river stretches) within XLSTAT 2010. Table 4.2 summarises the Eigen values, % variance and cumulative % variance explained by the estimated PCs. 71.5% of the variance in the data set is explained by the first eleven principal components, which all have Eigen values greater than one and thus explain more variance than the original indices from which they are estimated.

Table 4.2 Eigen values and variability results for the combined URS PCA

Principal Component	Eigen value	Variance explained (%)	Cumulative Variance explained (%)
1	9.03	21.01	21.01
2	6.34	14.75	35.75
3	3.19	7.43	43.18
4	2.07	4.81	47.99
5	2.04	4.74	52.73
6	1.78	4.13	56.86
7	1.44	3.36	60.22
8	1.38	3.20	63.42
9	1.24	2.90	66.31
10	1.22	2.85	69.16
11	1.01	2.34	71.50

The first two PCs explain 35.7% of the variance, slightly lower than the 40% explained by the analysis of the historic data set alone. However, these two PCs described similar environmental gradients to those previously estimated (see Figure 4.5) and the remaining PCs with Eigen values >1 added little synthetic information to these first two

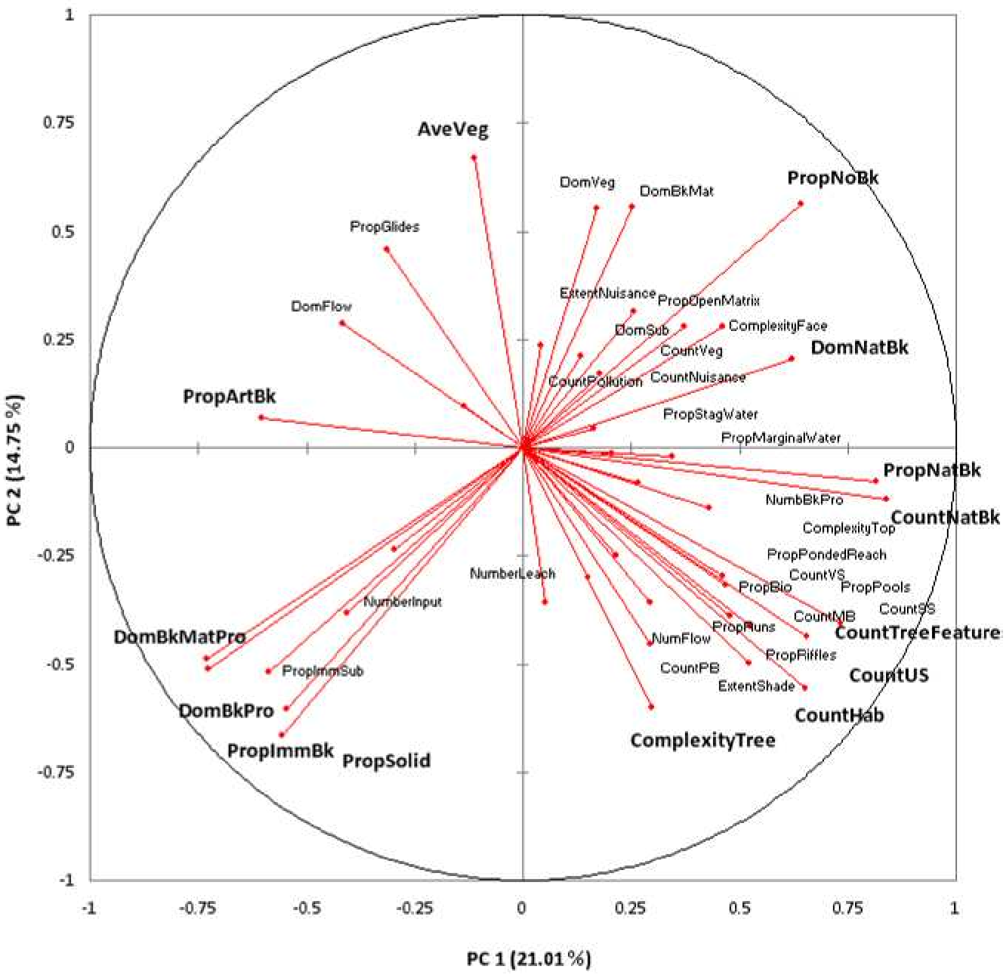


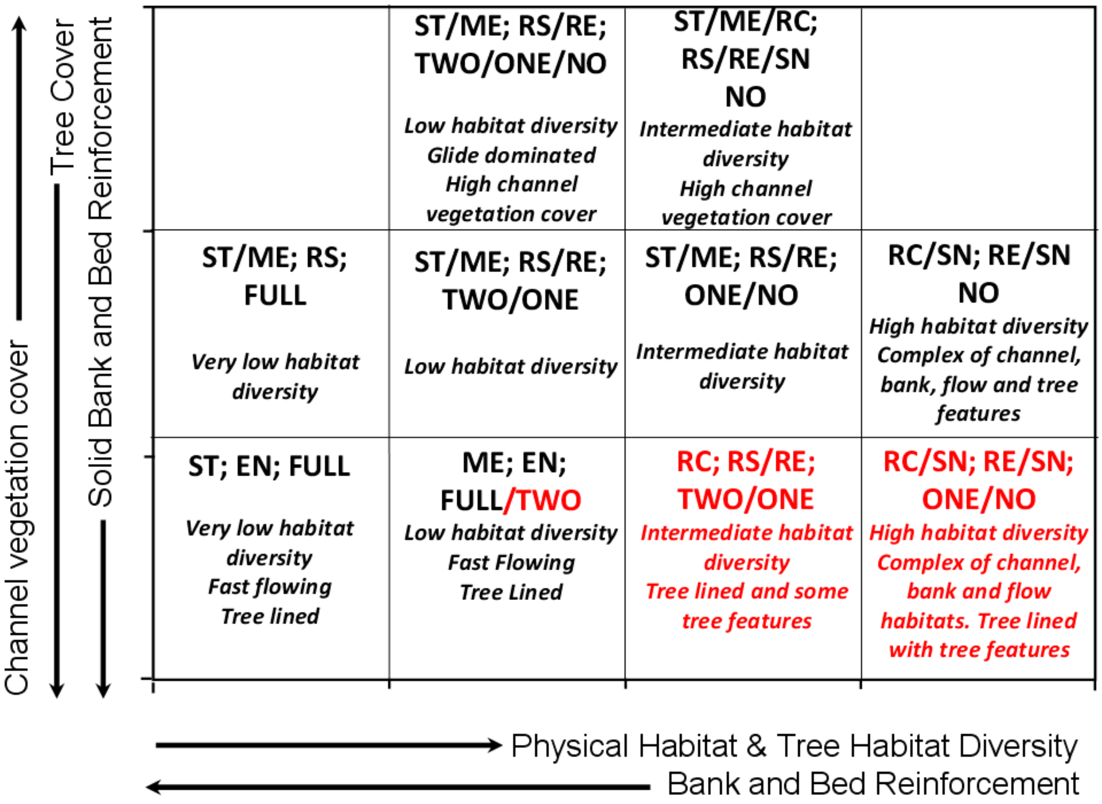
Figure 4.5 Plot of loadings of the URS indices on the first two PCs of a PCA applied to the combined London and historic data sets. (indices with loading 'outside' +/-0.6 on either PC are emboldened)

environmental gradients since they described gradients after extraction of the first two PCs that related to only one of the original indices. Table 4.3 lists those URS indices with loadings of ≥0.6 or ≤ -0.6 on the first two PCs and thus those that best describe the two environmental gradients. All index loadings on PC1 and PC2 are illustrated in Figure 4.5 with those carrying high loadings emboldened. The vectors in Figure 4.5 illustrate the direction and strength of associations between the indices and the two PCs and also the configuration of clusters of associated indices.

When the PC scores for the URS stretches were plotted on the scatter graph and then sorted by engineering type (planform, cross profile and level of reinforcement) Gurnell et al. (2007) found that distinct engineering types plotted in particular areas of the scatter graph and possessed particular combinations of habitat types and complexity which were used to develop the URS matrix. Inclusion of the London data in the analysis did not change the nature of the environmental gradients described by the PCs but it did extended the spatial coverage of the plot area between the two PCs. As a result, it was possible to develop an extended URS matrix (Figure 4.6, new elements in red text) which will be fully explored below as the London data are investigated in increasing depth.

Table 4.3 Code names, full names and loadings of the URS indices on PC1 and PC2, for those indices with loadings exceeding 0.6.

URS Index code	**URS Index Full name**	**Loading of index on PC 1**
DomBkMatPro	Dominant Bank Material Protection Type	-0.730
DomBkPro	Dominant Bank Protection Category	-0.727
PropArtBk	Proportion Artificial Bank Profile	-0.604
DomNatBk	Dominant Natural Bank Profile Type	0.622
PropNoBk	Proportion No Bank Protection	0.641
CountHab	Count of Habitat Types	0.651
CountUS	Count of Unvegetated Side Bars	0.656
CountTreeFeatures	Count of Tree Features	0.735
PropNatBk	Proportion Natural Bank Profile	0.816
CountNatBk	Count of Natural Bank Profile Types	0.838
		Loading of index on PC 2
PropSolid	Proportion Solid Bank Protection	-0.666
PropImmBk	Proportion Immobile Bank Materials	-0.605
ComplexityTree	Complexity Tree Cover	-0.601
AveVeg	Average Channel Vegetation Cover	0.669



	ST/ME; RS/RE; TWO/ONE/NO *Low habitat diversity* *Glide dominated* *High channel vegetation cover*	**ST/ME/RC; RS/RE/SN NO** *Intermediate habitat diversity* *High channel vegetation cover*	
ST/ME; RS; FULL *Very low habitat diversity*	**ST/ME; RS/RE; TWO/ONE** *Low habitat diversity*	**ST/ME; RS/RE; ONE/NO** *Intermediate habitat diversity*	**RC/SN; RE/SN NO** *High habitat diversity* *Complex of channel, bank, flow and tree features*
ST; EN; FULL *Very low habitat diversity* *Fast flowing* *Tree lined*	**ME; EN; FULL/TWO** *Low habitat diversity* *Fast Flowing* *Tree Lined*	**RC; RS/RE; TWO/ONE** *Intermediate habitat diversity* *Tree lined and some tree features*	**RC/SN; RE/SN; ONE/NO** *High habitat diversity* *Complex of channel, bank and flow habitats. Tree lined with tree features*

Figure 4.6 URS matrix illustrating the original matrix in black and extensions identified from the London data set in red. Stretch engineering codes: Planform (ST= engineered straight, ME=engineered sinuous, RC=recovering, SN=semi-natural);Cross Profile (EN=enlarged, RS=re-sectioned, RE=restored, SN=semi-natural); Reinforcement (NO=none, ONE=one bank, TWO=both banks, FULL=full reinforcement)

4.3.2 Validation of London URS data: Engineering type

The scores for the surveyed river stretches on PC1 and PC2 are displayed as a scatter graph in Figure 4.7, allowing comparison between the plotting positions of the London and historic data sets. The London stretches show a wider distribution than the historic data, effectively filling the central and lower areas of the plot and thus removing much of the ‘arch’ in the historic data and indicating additional characteristics within the London stretches.

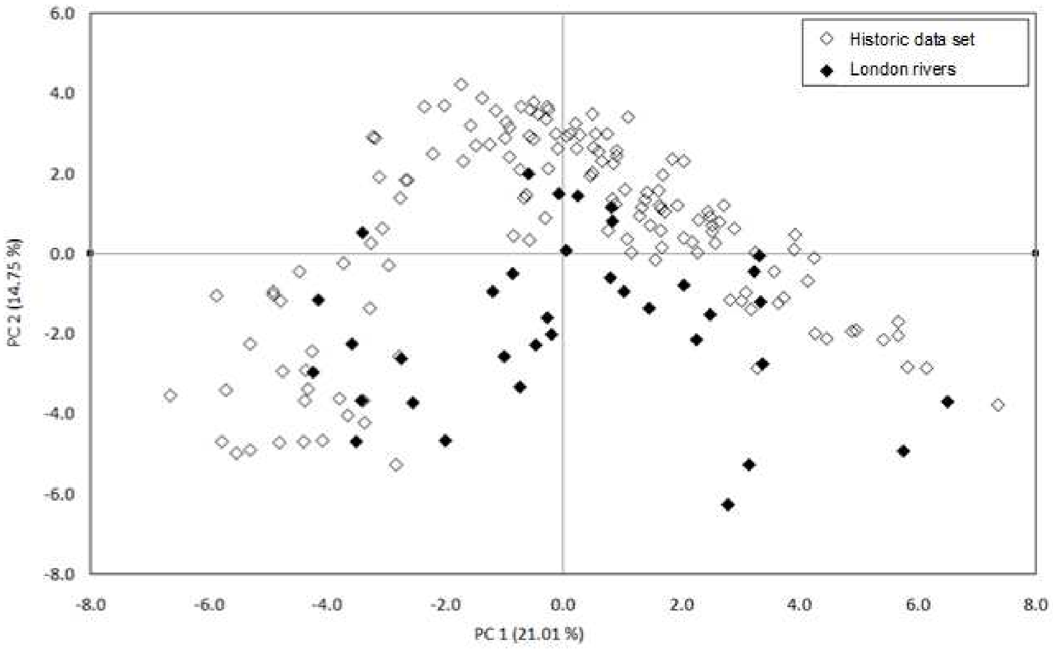


Figure 4.7 Scatter plot of URS stretch scores on the first two principal components of the PCA estimated from URS index values, highlighting the London and historic data sets

When the stretches within the combined data are labelled according to their engineering type (in terms of planform, cross profile and reinforcement level) and displayed graphically (Figures 4.8 a-c), it is possible to investigate in detail whether the London stretches fit the pattern described by the historic data and thus the original URS matrix.

(a) Planform

The distribution of stretch planform type (Figure 4.8a) reveals that engineered (straight and sinuous) channels dominate the lower left hand part of the plot (area C) with low scores on both PC1 and PC2. Moving to the right along the PC1 axis, the London data also indicate a transition towards semi-natural planforms, including the outlying data points in area D of the graph. The presence of a recovering site in area B also corresponds to the location of these types within the historic data.

(b) Cross-profile

When the stretches are labelled according to their cross profile type (Figure 4.8b), the distributions of stretches in both the historic and London data sets indicate that the most heavily modified, enlarged or re-sectioned channels, are mainly distributed towards the lower end of the PC1 axis, dominating area C of the graph. There is however a less distinct separation between enlarged and re-sectioned channels within the London data set, where the data indicate a higher frequency of enlarged channels that have high scores on the PC1 axis than was recorded for the historic data. These findings reflect the challenges of assigning a single cross-profile type. Many channels were both re-sectioned and enlarged, providing potential for misclassification (although recording rules determine that where both occur, the channel should be recorded as enlarged). The distribution of semi-natural and recovering engineered cross-profiles in the London data set, including the outlying data points in area D, also concurs with the expected position for such types within the URS matrix.

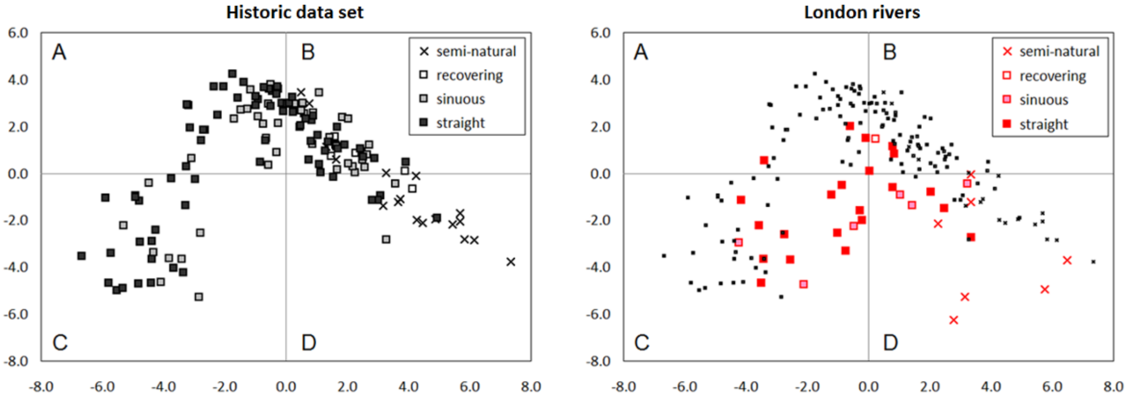
(c) Level of reinforcement

The levels of reinforcement observed in the London stretches (Figure 4.8c), demonstrate a further similarity with the historic data, with the most heavily reinforced sites located in area C. For both data sets, stretches with no reinforcement score highly on the PC1 axis, plotting in graph areas B and D. The distribution of London stretches with ‘one bank-’ or ‘both banks only’ reinforced are not clearly separated, but together occupy the (previously unfilled) mid-range of scores on the PC1 axis coupled with low scores on PC2 (in areas C and D).

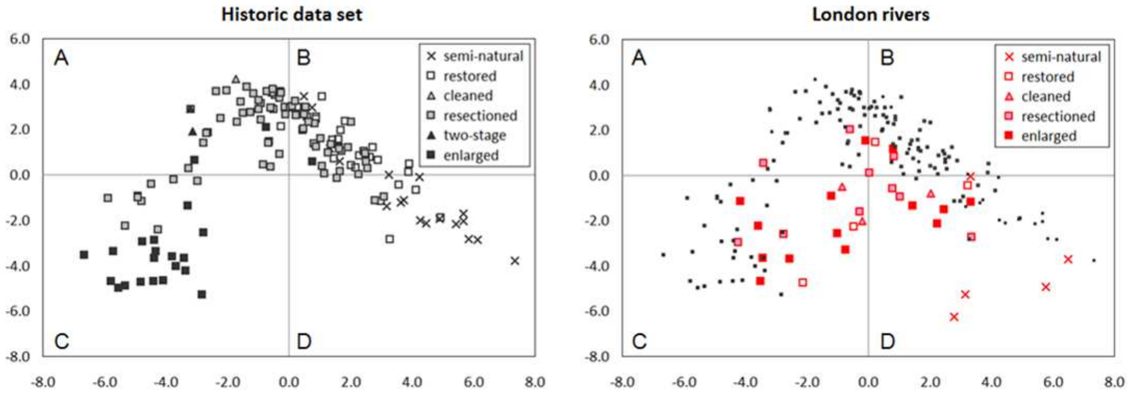
(d) Overview

When compared to the original URS matrix, the London stretches that fall beyond the plotting positions of the historic data, with low scores on PC2 and intermediate to high scores on PC1, appear in accordance with the engineering types that might be expected in those areas of the matrix. Stretches within the lower middle area of the plot (area C) appear to represent mainly channels that are engineered straight, enlarged or re-sectioned, and reinforced (one or both banks only). The outlying data points in area D have semi-natural planforms with semi-natural or recovering cross sections but have some bank reinforcement. These engineering characteristics are also appropriate to this area of the matrix.

(a) Planform



(b) Cross-profile



(c) Reinforcement

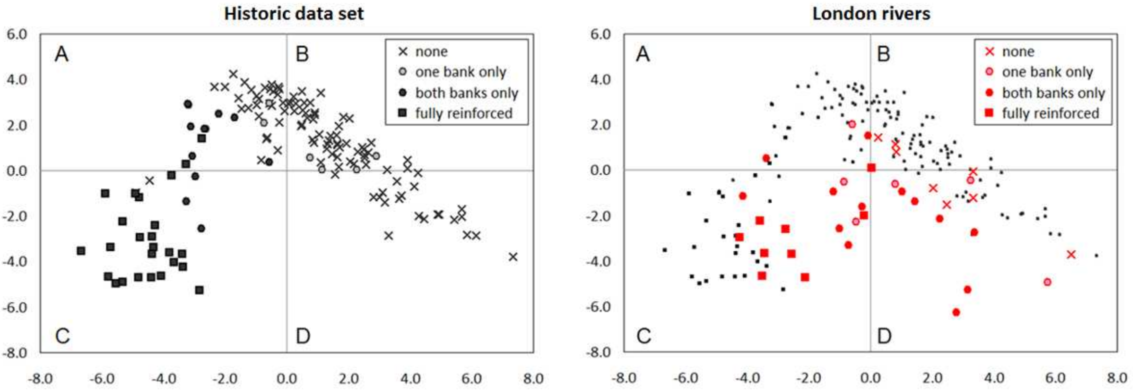
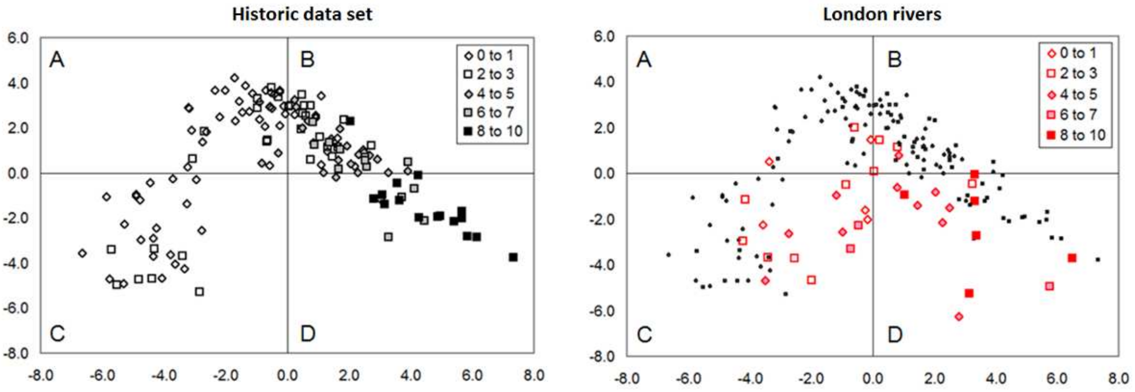


Figure 4.8 Comparison of (a) planform, (b) cross profile, (c) level of reinforcement types in the historic (left graph) and London (right graph) data sets according to stretch scores on PC1 and PC2

4.3.3 Validation of London URS data: Habitat

The percentage frequency distributions of two URS indices: Counts of Tree Features and In-Channel Habitat Types (section 4.2.2) illustrate some basic similarities and differences between the historic and new datasets. Figures 4.9 and 4.10 display scatter plots of the historic and London stretches according to their scores on PC1 and PC2 and coded according to the values of these two indices at each stretch revealing further information about the nature and extent of concurrences and contrasts.

The ‘Count of Tree Features’ index (Figure 4.9) shows similar distributions for the London and historic stretches, with higher counts concentrated at stretches with high scores on PC1 and low scores on PC2, towards the lower right side of the plot (area D). The outlying London stretches in area D each display relatively high counts of tree features as would be expected in this area of the URS matrix. Similar patterns are also observed for the number of in-channel habitat features in the historic and London stretches (Figure 4.10). The London stretches with low scores on PC2 in areas C and D of the graph) indicate an increase in the number of habitats with increasing scores on PC1 indicating increasing morphological diversity.



Historic data set

London rivers

Figure 4.9 Comparison of the number of types of tree features (CountTreeFeatures) recorded in the historic (left graph) and London (right graph) data sets according to stretch scores on PC1 and PC2

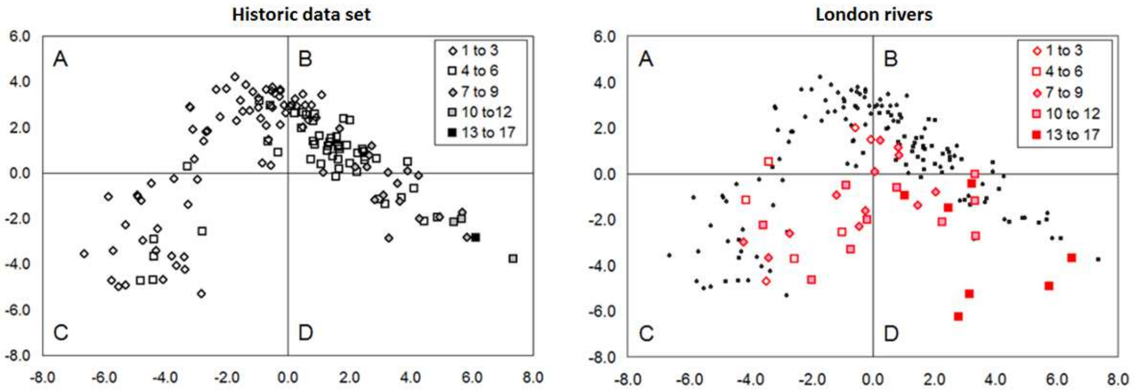


Figure 4.10 Comparison of the number of types of in-channel habitat (CountHab) recorded in the historic (left graph) and London (right graph) data sets according to stretch scores on PC1 and PC2.

A review of the photographic evidence for the two of the outlying data points in area D (Figure 4.11) shows that these stretches both included substantial riparian and marginal tree habitats (e.g. submerged roots, woody debris and overhanging boughs) as well as in-channel physical features (e.g. (un)vegetated bars and riffles). In both cases, the sites displayed considerable signs of neglect with reinforcements in poor condition alongside indications of geomorphological recovery as in–channel sediment accumulations create bars and berms, narrowing the channel width and inducing habitat complexity.

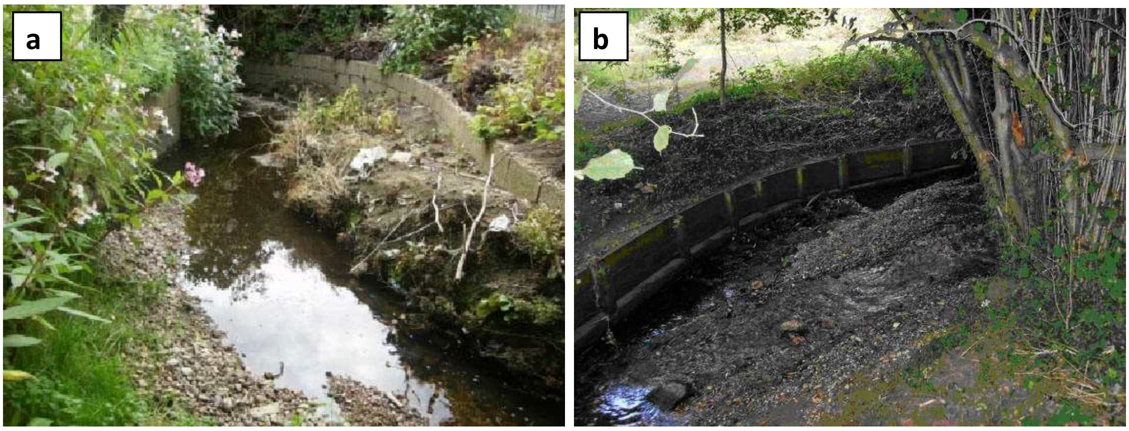


Figure 4.11 Two views of stretches on the River Brent at (a) Deans Brook and (b) Mutton Brook, represented by outlying data points on the PCA plot, showing derelict bank reinforcements and habitat features.

4.3.4 Conclusions concerning differences between the historic and London data sets

A comparison of the plotting positions of the London and historic URS stretches with respect to the first two PCs and in relation to their engineering type and the values of two habitat feature indices reveals a good match between the characteristics of London stretches and the predictions of the original URS matrix. Furthermore, where the London data fill the previously empty spaces within the matrix, their characteristics conform to what would have been predicted from the environmental gradients described by the two PCs.

Several of the differences observed between the two data sets appear to be related to regional differences in river management, in particular the use of different reinforcement types, particularly toe boarding (which was only recorded in London), a lack of riparian management and the generally poorer condition of existing bank protection for many stretches of London river, permitting notable geomorphological recovery despite the presence of bank reinforcement at several stretches (Figure 4.12).

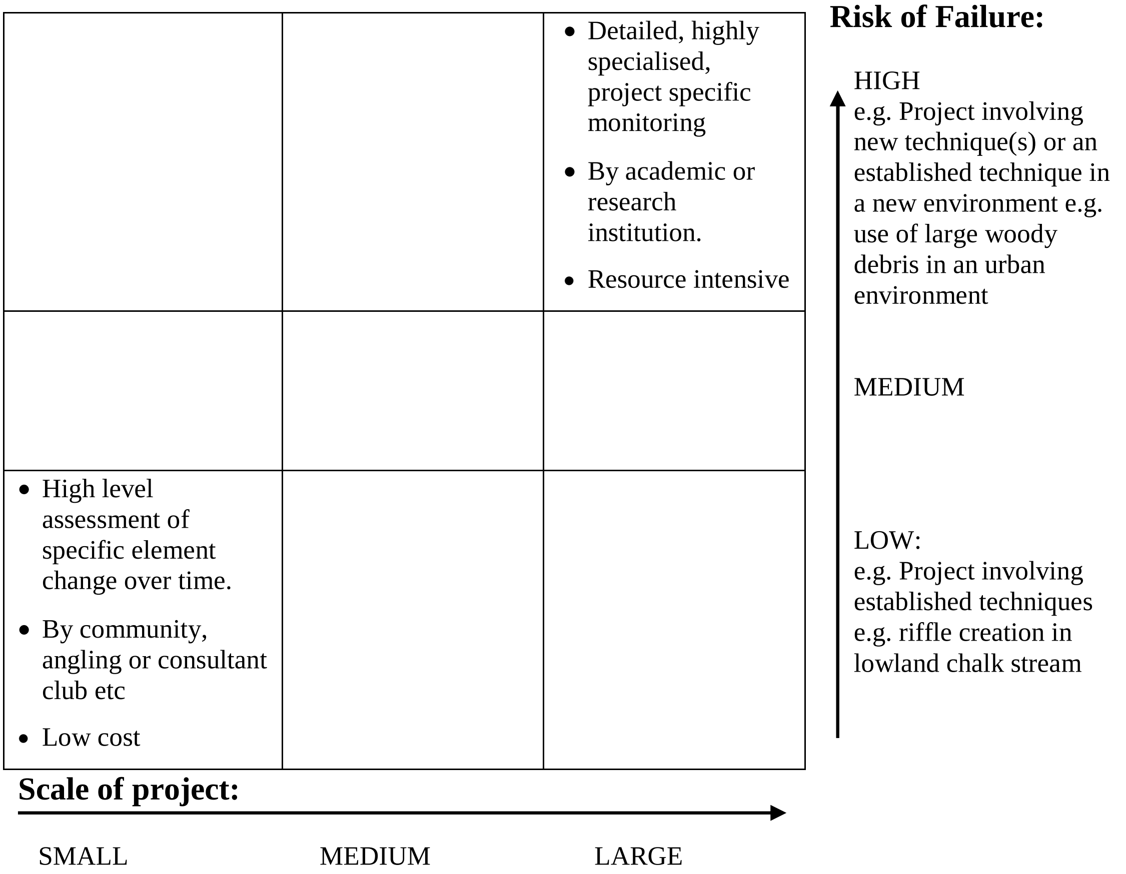
Figure 4.12 View of decaying toe board reinforcements with signs of physical recovery on the River Brent.

4.4 Reach scale investigation of the impacts of restoration for two paired stretches using the URS

Ongoing concerns of local communities and urban river managers relating to flood risk management, conserving biodiversity and building resilience to climate change, are increasingly reflected in environmental policy targets (Chapter 5). Such levels of policy support and encourage urban river managers to seek combined solutions through either reactive or planned interventions and may provide opportunities for integrated river and riparian rehabilitation ranging from minor in-stream enhancements to major restoration works for river channels and adjacent green spaces.

A long recognised gap in river management strategies is the lack of consistent post project appraisal (PPA, Downs and Kondolf, 2002; Wharton and Gilvear, 2006; Kondolf et al. 2007). The lack of data for PPA is usually associated with funding shortfalls and is therefore primarily a political (i.e. social) rather than an environmental science issue. The River Restoration Centre report ‘Practical River Appraisal Guidance for Monitoring Options’ (RRC, 2011) represents an initiative that encourages restoration practitioners to include monitoring within project budgets to support ongoing channel management strategies. The PRAGMO guidance provides advice on the selection of suitable monitoring approaches according to the scale of the project and the risk of the works failing to meet restoration objectives. A series of two dimensional grids are used to guide river managers based upon particular objectives (Figure 4.13). Both the industry standard River Habitat Survey (RHS) and its urban modification, the URS are represented within PRAGMO as monitoring methods which may be applied to medium to large size projects carrying all levels of risk.

The PCA results derived for the London URS dataset, provide an opportunity to explore the potential of the URS as an assessment tool for post restoration appraisal. The two recently restored case study stretches on the rivers Brent and Ravensbourne were compared to adjacent unrestored stretches (to indicate pre-restoration stretch conditions), providing a proxy for before and after major restoration works. The details of the restoration intervention works are summarised in Table 4.4.



Risk of Failure:

HIGH
e.g. Project involving new technique(s) or an established technique in a new environment e.g. use of large woody debris in an urban environment

MEDIUM

LOW:
e.g. Project involving established techniques e.g. riffle creation in lowland chalk stream

		• Detailed, highly specialised, project specific monitoring • By academic or research institution. • Resource intensive
• High level assessment of specific element change over time. • By community, angling or consultant club etc • Low cost		

Scale of project:

SMALL MEDIUM LARGE

Figure 4.13 PRAGMO matrix of project scale vs risk of failure to meet objectives with indicative guidance for Small scale/Low risk and Large scale/High risk projects (RRC, 2011)

Table 4.4 Summary information for restored and adjacent URS stretches

Stretch no.	URS Stretch Name	Stretch length (m)	Date of works	Type of intervention
RV05	Ravensbourne Ladywell Fields South	500	2007	Enhancement: wooden toe board removal
RV06	Ravensbourne QUERCUS	300	2008	Creation: new sinuous channel; floodplain landscaping
BR10	Tockyngton Park North	500	n/a	None
BR11	Tockyngton Park South	300	2004	Restoration: re-profiled sinuous channel; floodplain landscaping

4.4.1 Stretch Habitat Quality Index and Thematic Classifications

The URS methodology provides two types of assessment which can be used to describe and compare the relative condition of urban river stretches. Comprising of: (i) a series of three component classifications (for Materials, Physical Habitat and Vegetation Structure) and their combination within the Stretch Habitat Quality Index (SHQI, Boitsidis et al. 2006), and (ii) the PCA-based URS matrix (section 3.2.2).

The SHQI results for all the London stretches and thematic classifications for the paired stretches on the Rivers Brent and Ravensbourne are illustrated in Figures 4.14 and 4.15, respectively.

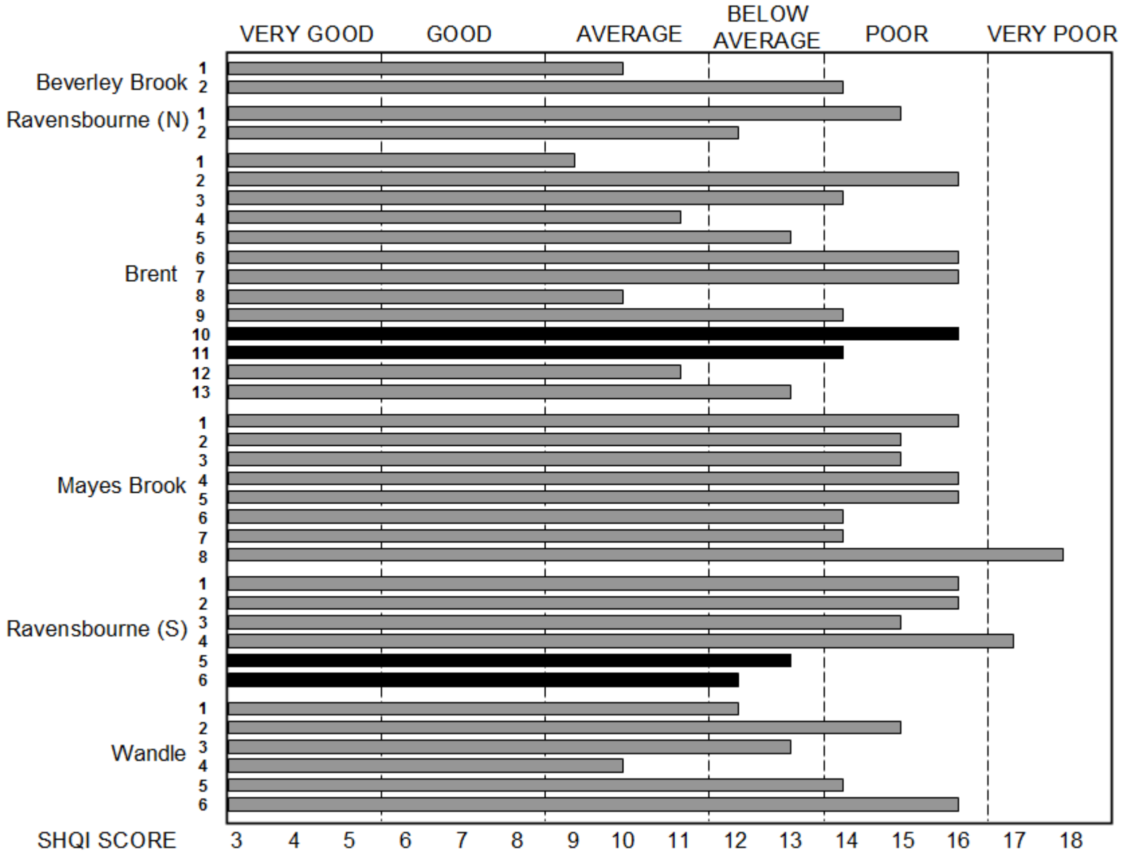


Figure 4.14 SHQI scores for the London data set, with the paired comparison stretches on the Brent and Ravensbourne shown in black

The SHQI bar chart (Figure 4.14) provides a rapid overview of the variability in habitat condition across the surveyed London rivers, which range from average to very poor. The approximate upstream to downstream arrangement of the stretches on the chart displays wide variability within individual rivers rather than a simple downstream gradient of deteriorating condition for most catchments. These results reflect the longitudinal fragmentation of urban river profiles into reach ‘units’ described by Clifford (2007).

The paired restored/un-restored stretches (shown in black) in both cases indicate an improved condition for the restored (downstream) stretches (BR11, RV06) compared to the un-restored (upstream) stretches. The greatest difference is seen between the Brent stretches (BR10, BR11) where the transformation of the downstream river channel has produced quite a large change in SHQI score although the SHQI class remains ‘Poor’ for both stretches. The smaller difference observed for the Ravensbourne stretches (RV05, RV06) indicate a better condition overall and a smaller degree of change in habitat quality associated with the restoration works at Ladywell Fields. Recent minor enhancements carried out on the upstream (unrestored) stretch may also have improved habitat condition at this site.

For both paired stretches, more detailed information can be gained from the URS thematic classification scores (Figure 4.15). A comparison of the URS class scores for each pair of stretches indicates that in both cases, differences in materials classifications are driving the overall differences in SHQI score. The unexpectedly higher (worse) score for Physical Habitat at site BR11 reflects the recording of >50% re-sectioned bank profile as ‘artificial’ which has overridden the high number of habitat types at this site in the automated calculations. The dependence of the classification upon only a small number of discriminating indices has magnified this subjective error. This highlights the importance of providing clear guidance to ensure that surveyors are correctly recording key features.

4.4.2 URS matrix and PCA-based results for the Brent and Ravensbourne paired stretches

The differences between the restored/un-restored stretches may also be investigated via their scores with respect to the first two PCA components and position within the URS matrix. The position of each stretch point is based upon the combined information of 43 aggregate URS environmental indices and therefore provides a more sensitive interpretation of the differences which may be associated with the restoration works.

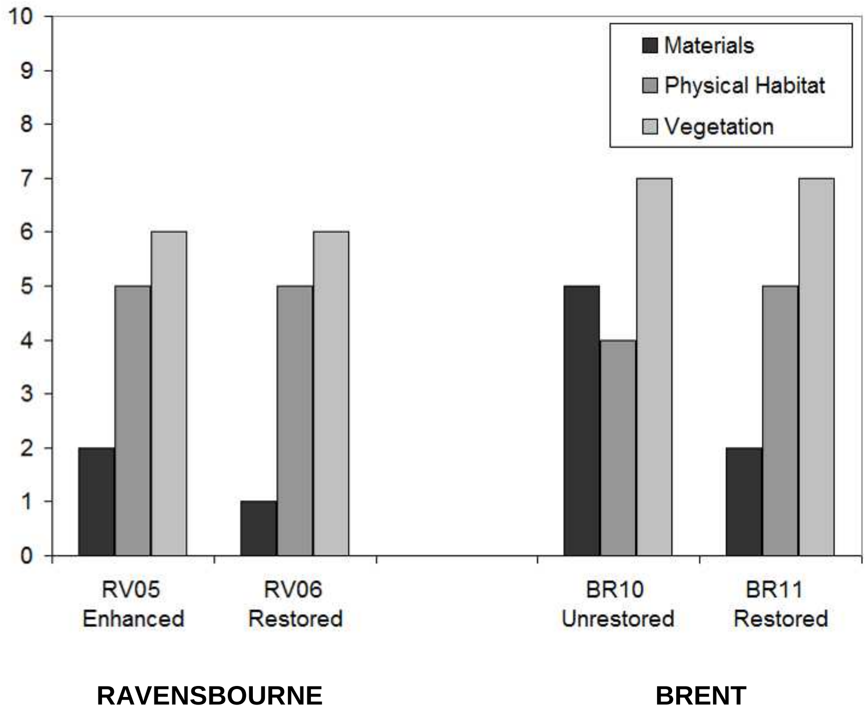


Figure 4.15 URS thematic classification results for adjacent restored and unrestored stretches on the Ravensbourne and Brent

When the relative positions of the pairs of restored and unrestored stretches on the rivers Ravensbourne (RV05, RV06) and Brent (BR10, BR11) are superimposed on the scatter plot of stretch scores on PC1 and PC2 (Figure 4.16a) and URS Matrix (Figure 4.16b), it is possible to identify clear shifts between the unrestored and restored condition that can be interpreted in conjunction with photographic evidence for each site (Figures 4.17a-d).

4.4.2.1 River Brent at Tockyngton Park

The unrestored channel of the river Brent at Tockyngton Park (BR10, Figure 4.17 a) has both banks reinforced with solid (concrete) reinforcement so that despite the presence of mature trees on the bank tops, there are very few tree features or other physical habitats in the channel and margins. On the URS Matrix the unrestored stretch on the Brent (BR10) plots in an area of low habitat diversity and relatively high channel engineering (Figure 4.16).

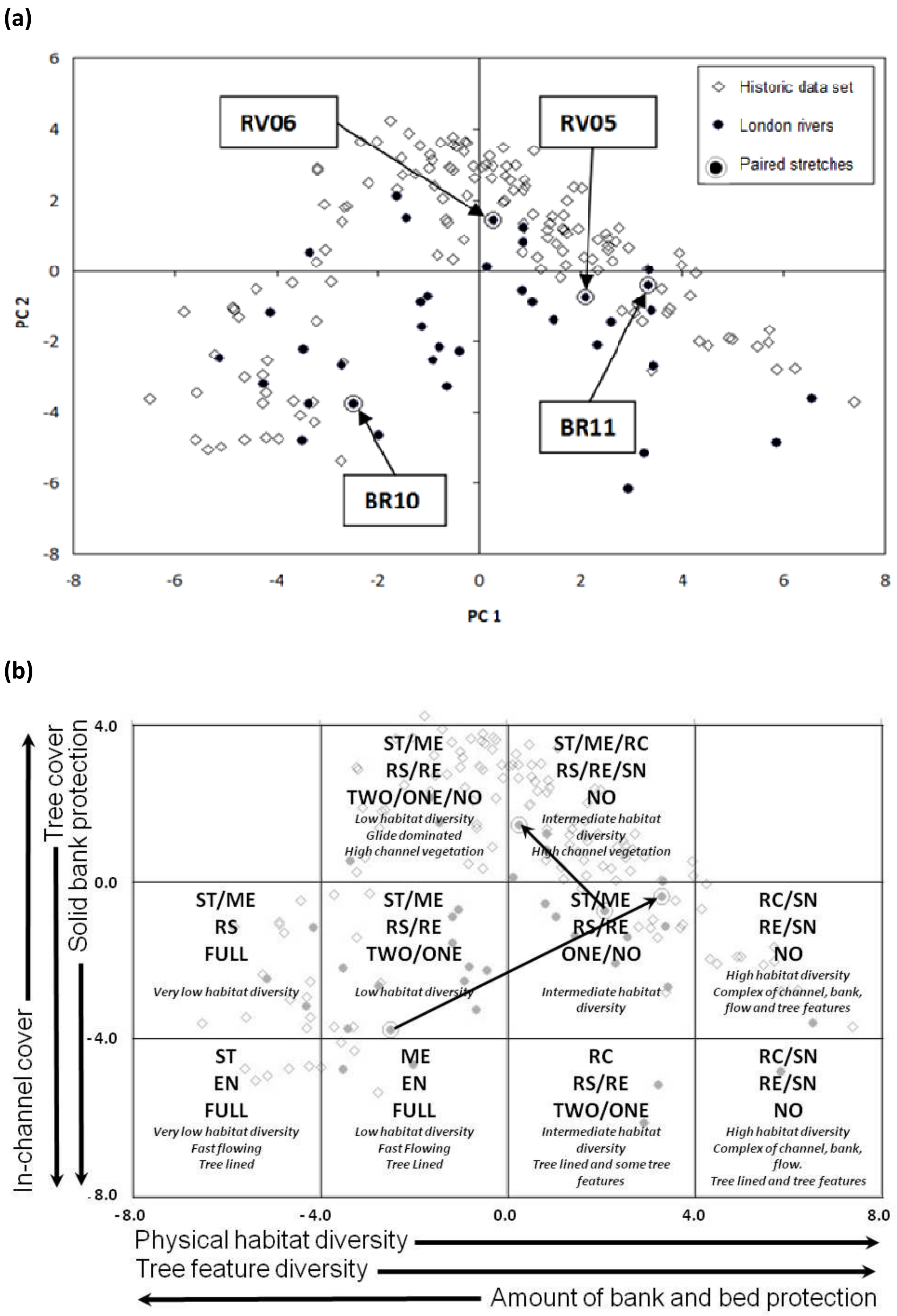


Figure 4.16 The two pairs of restored and unrestored stretches (a) located on the scatter plot of stretch scores on the first two PCs and (b) showing the shift across the URS matrix from the unrestored to restored condition

For the restored Brent stretch (BR11), restoration works included the construction of a new sinuous channel with minimal soft channel engineering consisting of coir matting and willow spiling planted over crushed concrete buried within the outside of bends where the underground infrastructure required protection. On stretch BR11, the restoration works involved the removal of the heavy reinforcement and the introduction of increased morphological complexity. Although some bank profiles still retain a ‘re-sectioned’ appearance, overall the channel form and riparian vegetation have become well established since the restoration and now provide a good range of habitats. This transformation has allowed the stretch to achieve a much higher score on PC1 relative to the unrestored stretch reflecting the large differences in the engineering and habitat characteristics between the two stretches. The restored stretch is located well towards the positions of the most complex semi-natural and recovering stretches on the URS matrix.

4.4.2.2 River Ravensbourne at Ladywell Fields

At Ladywell Fields, both the un-restored (RV05) and restored (RV06) stretches of the River Ravensbourne are situated in adjacent sections of a public open space which provides a valued piece of green infrastructure within the borough of Lewisham and is used both as a destination and connecting route by local people. The unrestored stretch (Figure 4.17c) is a mature, neglected and fenced-off channel that follows the park boundary. Recent enhancement works have been undertaken along the stretch to remove wooden toe-board bank protection resulting in some morphological recovery of the cross profile. The stretch has mature tree cover along its margins. Despite the over widened cross section and straightened planform, the relatively complex bank vegetation supporting a range of tree features and relatively high number of physical habitat types within the channel position the un-restored stretch (RV05) in an area of intermediate habitat diversity on the PCA scatter plot and URS Matrix (Figure 4.16).

In contrast, the restored stretch (RV06) is a newly created (weir-bypass) channel into which approximately 60% of the river flow is diverted from the old channel using a new low rip rap weir. The new sinuous channel winds through the re-landscaped public green space and flood storage area before rejoining the original channel further downstream within the park boundaries (Figure 4.17d).

Figure 4.17 Views of the un-restored and restored stretches on the river Brent at Tockyngton Park and river Ravensbourne at Ladywell Fields: (a) Brent (BR10), unrestored; (b) Brent (BR11), restored in 2004; (c) Ravensbourne (RV05):enhanced in 2007, (d) Ravensbourne (RV06), restored in 2008.

The newly created ‘restored’ channel has no reinforcement and was at the time of survey in its first growing season since works were completed. The restoration has created a more complex planform than was found in the unrestored stretch, however relatively fewer physical habitat types were observed during the survey, and the complexity of riparian and aquatic vegetation was low in comparison with the more mature unrestored stretch. On the URS matrix, this newly ‘restored’ stretch (RV06) has a lower score on PC1 in comparison with the unrestored stretch, reflecting the lower physical habitat and tree feature diversity, and a higher score on PC2 reflecting the lack of tree cover at this early stage of riparian vegetation development (Figure 4.16).

4.4.3 Conclusions regarding the classifications and URS matrix positions of the restored and unrestored paired reaches

The two restoration case study sites on the River Brent in Wembley and River Ravensbourne in Lewisham were compared to adjacent unrestored stretches using the URS thematic classification and SHQI scores; and the URS Matrix.

The two pairs of adjacent restored/un-restored river stretches were used to investigate the differences in biophysical habitat condition that are associated with river restoration intervention works at the restored stretches. The evidence presented in this section shows that in all cases changes in the biophysical condition of the restored river channels were demonstrated by the URS outputs. However the URS matrix and associated PC scores were found to be more robust (being less susceptible to subjective recording discrepancies), and able to communicate the most sensitive information about the integrated engineering:habitat condition of individual river stretches.

These two examples also suggest how restored stretches may migrate across the URS matrix through time as restored river function and channel adjustment processes develop and habitats mature following restoration. The examples provide evidence for how an integrated river assessment method such as the URS matrix and its related PC scores can be used to interpret and communicate the bio-physical condition of individual urban river stretches and post-restoration channel responses across disciplinary boundaries with non-river specialists or within a wider societal context especially when used in conjunction with locally specific information such as photographic evidence and restoration objectives.

4.5 Catchment scale investigation of restoration potential using the Urban River Survey

River responses to channel engineering, including restoration works, can often occur in other remote parts of the river system. They may occur upstream or downstream of channel modifications or interventions and develop at rapid or delayed response rates (Downs and Gregory, 2004). A catchment scale perspective on engineering:habitat relationships is therefore essential for urban river managers to understand the function and responses of river systems beyond the reach scale especially within an urban catchment where channels are typically modified by many different types of engineering. An integrated appreciation of engineering intervention and biophysical characteristics across a catchment river network is also crucial in the development of a coordinated strategy of targeted habitat improvements across the wider river ecosystem, for example to increase resilience opportunities of aquatic species to anthropogenic impacts (Webb, EA, Interview comment, 2010). By surveying accessible stretches upstream and downstream of potential restoration sites, it is also possible to provide a baseline for the appraisal of local and remote responses to restoration works and thus to evaluate the outcomes and sustainability of the restoration project across time and space.

Options to restore ecosystem function to river systems that have been impacted by channel engineering are typically constrained by the degree of river margin development, access to the channel and ownership of the riparian land. Opportunities for urban river restoration have in the past often been indirectly tied to the development of adjacent land or flood risk management. However, in recent years increased direct funding has become available to redress damage caused by historic engineering works (Scott, EA, Interview comment, 2009).

Where a range of restoration options exist, an integrated reconnaissance of an urban river system in terms of existing engineering and habitat bio-physical condition, and therefore the potential for ecological recovery at key locations across the catchment, could support feasibility assessments and stakeholder engagement during decision making processes and consultation with local community members and stakeholders. An interpretation of engineering and habitat condition along accessible stretches may also be useful in informing river managers of the locations where resources could be used most effectively to remediate specific physical pressures or where the habitat condition could make the most gains.

This section presents the results of an investigation into the biophysical habitat condition of all accessible parts of the Mayes Brook, including the case study (pre-restoration) stretch within Mayesbrook Park. A total of eight accessible stretches of 250-500m in length were surveyed along the unculverted reaches of the Mayes Brook between Mayesbrook Park and the River Roding (including the ‘Roundabout ditch’ tributary). This section begins with a description of the Mayes brook catchment (section 4.5.1) and brief details of each stretch (section 4.5.2). These set the context for an overview of the geomorphological and vegetation habitat features expressed through the URS thematic classifications and SHQI scores (section 4.5.3) and the URS matrix (4.5.4). A summary of the bio-physical condition of the Mayes brook catchment is then provided in 4.5.5.

4.5.1 Mayes Brook catchment overview

Mayes Brook is a tributary of the river Roding within the river Thames basin. The brook is estimated to be 7.4km in length and receives surface water from an approximate catchment area of 22 km^2 between its source north of Chadwell Heath and confluence with the Roding at Barking Creek. The exact source of the brook is difficult to determine as the reaches upstream of Mayesbrook Park are entirely culverted with the exception of the ponds at Goodmayes Park. An additional branch flowing from the west, joins the brook in the upstream culverted section (Figure 4.18).

The Mayes Brook catchment is underlain by superficial alluvial river terrace gravels over London Clay (LBBD, 2001) and is largely covered by residential housing in the upper catchment, with an increasing density of road and rail transport infrastructure and industrial estates in the lower catchment. The catchment also contains several public open spaces at Chadwell Heath, Goodmayes Park, and Mayesbrook Park as well as the private playing fields of several schools and Rippleside Cemetery all of which are located close to or along the riparian corridor of the Mayes Brook.

Locations for the starting points for each surveyed stretch are given in Table 4.5. (Where stretch lengths are less than 500m all survey count data are corrected within the calculations using an appropriate scaling factor).

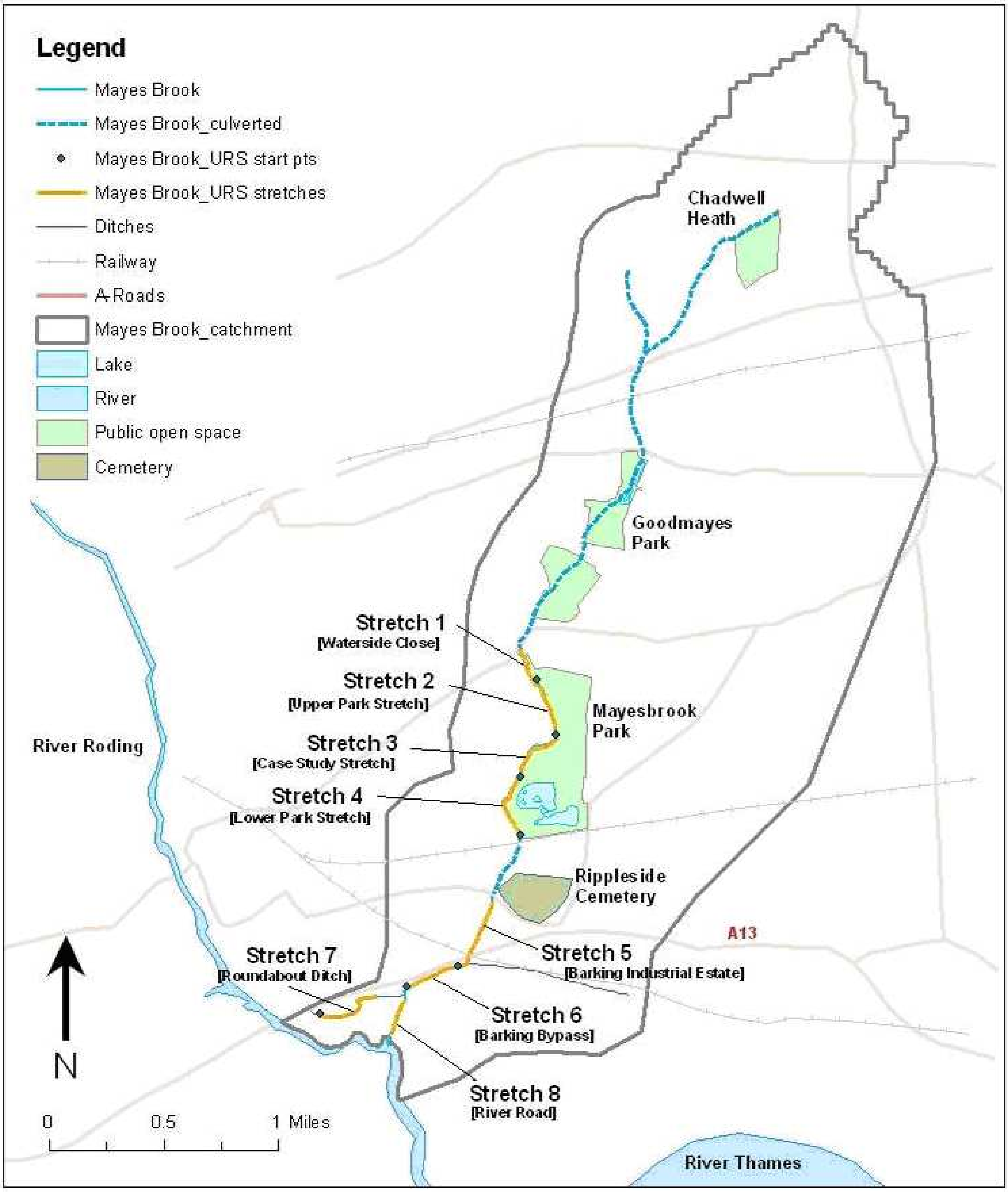


Figure 4.18 The Mayes Brook catchment showing the exposed and culverted river network and URS stretches

Table 4.5 Location of URS stretches

Stretch no.	URS Stretch ID	Stretch length (m)	Location	NGR (survey start point)
1	MB_001WC	300	Waterside Close	TQ4625285433
2	MB_002UP	400	Upper Park Stretch	TQ4638985040
3	MB_003CS	500	Case Study Stretch	TQ4614184748
4	MB_004LP	500	Lower Park Stretch	TQ4614084343
5	MB_005BI	500	Barking Industrial Estate	TQ4570483413
6	MB_006BB	500	Barking Bypass	TQ4534383277
7	MB_007RD	500	Roundabout Ditch	TQ4472983080
8	MB_008RR	250	River Road	TQ4530183171

4.5.2 Mayes Brook stretch descriptions

Stretch 1: Waterside Close [MB_001WC]

The Mayes Brook emerges from the culverted reaches upstream of this stretch and flows through an enclosed area of amenity grassland without public access at the north-west boundary of Mayesbrook Park (Figure 4.19a). The slightly sinuous trapezoidal channel is fully reinforced with brick tiles and partially shaded by semi-continuous tree cover along the east bank. A second screened inlet close to the main inlet channel marks the confluence of a culverted overflow channel from Goodmayes Park. During site visits the screen was heavily covered with litter providing a first indication of the water quality issues for the brook. Two other storm flow inlets were also observed along this stretch. After 300m a sharp double bend marks a change in channel engineering and the end of the stretch, here a drop in level produces a small chute as the brook flows into stretch 2.

Stretch 2: Upper Park Stretch [MB_002UP]

The Mayes Brook shows major changes in the engineering of its planform and cross-profile in this stretch. The brook flows within a straightened, over-widened and deepened channel with a trapezoidal cross profile that is reinforced with concrete along the bank toe and channel bed. The channel reinforcements are heavily overlain with deposited sediments along much of the stretch, which form a semi-continuous succession of sidebars colonised by emergent reeds and sedges including large stands of *Sparganium erectum*. These depositional features within the re-sectioned channel confine a narrow gravel bed channel that divides and meanders around the vegetated bars. At the time of survey, the channel had recently been cleaned with all in-channel and lower bankside vegetation trimmed back to remove the superficial foliage but retaining the structure of the depositional features (Figure 4.19b).

Along stretches 2 to 4 located adjacent to Mayesbrook Park, the brook is disconnected from its floodplain by low embankments and from the local community by a high steel palisade fencing that runs along both bank tops forming a boundary between Mayesbrook Park to the east and the Leftley housing estate to the west.

Stretch 3: Case study stretch [MB_003CS]

Immediately adjacent to the site of the planned restoration works, the Case Study stretch extends 500m upstream of a flood protection sluice. A steel palisade fence runs continuously along the embanked eastern bank top. To the west, the physical boundary between the brook and adjoining residential properties consists of a mix of garden fences and riparian hedgerows. This stretch has been straightened, over-widened and re-sectioned. Historic concrete reinforcements on the bank toe and channel bed are broken up in places and overlain with gravels and silt at the channel margins. Vegetated side bars narrow the channel width along much of the stretch (Figure 4.19c), giving it a similar appearance to stretch 2. However, the presence of engineered bends, two large inlets and a small footbridge have induced some additional hydraulic and physical habitat diversity, such as sizeable scour pools around the inlets. Evidence of point pollution included litter deposited immediately downstream of the inlets.

Stretch 4: Lower park stretch [MB_004LP]

Stretch 4 extends downstream from the flood sluice forming the south western boundary between Mayesbrook Park and the adjacent housing estate. Here the character of the brook is similar to upstream stretches 2 and 3 with an enlarged, re-sectioned cross-profile. The steel palisade fence continues along the left bank top with intermittent residential garden boundary fences along the right bank top. Along the right bank top and face, the adjoining residential gardens encroach onto the banks and include areas of planting as well as dumping of garden waste. The channel is impacted by a footbridge at the south western entrance to the park and two road drainage inlets, where visual signs

Figure 4.19 Views of surveyed stretches of the Mayes Brook: (a) Stretch 1:Waterside Close; (b) Stretch 2: Upper Park stretch; (c) Stretch 3: Case Study stretch; (d) Stretch 4: Lower Park stretch;(e) Stretch 5: Barking Industrial Estate; (f) Stretch 6: Barking Bypass; (g) Stretch 7: Roundabout Ditch; (h) Stretch 8: River Road.

of poor water quality were observed, including a plume of opaque water entering the brook. Between the brook and the park lakes, the adjacent area of parkland includes a plantation of trees and mature hedgerow, but these are separated from the brook by the palisade fence. At the time of surveying, the in-channel vegetation along this stretch had recently been trimmed back as part of the EA flood management regime (Figure 4.19d). At the most south-westerly point of the park the Mayes Brook passes through a large screening grill and beneath the railway line into a culverted section. Terrestrial and aerial maps and images suggest that the culverted brook runs near to the boundary of the Rippleside Cemetery between these locations.

Stretch 5: Barking Industrial Estate [MB_005BI]

Between the A123 (Ripple Rd) and A13 (Alfreds Way) the Mayes Brook runs between the Barking Industrial Estate and residential housing with a riparian corridor approximately 30m wide, to the west of the channel only. At the south of this corridor a 50- 60m wide flood storage area has been constructed behind grassed flood bunds fitted with sluices to control the release of stored flood waters. This stretch is uniform with a straightened and over-widened trapezoidal channel. The banks are also uniformly vegetated with few trees or shrubs to generate woody debris or tree related habitat features. Within the channel some marginal macrophytes and side bars are established providing a degree of habitat variety (Figure 4.19e). Immediately downstream of the flood storage area the brook passes below the A13 and railway line through a short culvert.

Stretch 6: Barking Bypass [MB_006BB]

A short distance downstream of the A13 (Barking Bypass) culvert, at the confluence with a heavily vegetated drainage channel, the brook changes abruptly to a more westerly course as the channel runs parallel to the Barking bypass. Steep embankments to the north form part of the bypass infrastructure constraining the course of the brook along the road boundary. To the south, the brook is adjoined by a partially tree-lined riparian corridor adjacent to residential and industrial estates. The uniform character of the channel is similar to stretch 5, but the southern banks are lower and the channel supports more prominent vegetated side bars. At the downstream end of the stretch, close to the junction of the A13 and River Road the river corridor widens to include another constructed flood storage area which incorporates a bunded flood water meadow with sluices to control outflows (Figure 4.14f).

Stretch 7: Roundabout Ditch [MB_007RD]

Approximately 250m upstream of its confluence with the River Roding the Mayes Brook is joined by a tributary from the west, known as the Roundabout Ditch. In contrast to the final stretch of the brook itself, this stretch is much less heavily reinforced. The Roundabout Ditch has similar aquatic habitat characteristics to stretch 6, although the channel is less heavily engineered. The less straightened planform follows a convoluted route around housing and the Abbey Wharf industrial estate. In places the channel is choked with vegetation with very low flow energy and high levels of deposited silt (Figure 4.19g). Due to historic sightings of water vole along the lower reaches of the Mayes Brook, this stretch was also surveyed to record the characteristics of potential water vole habitat in this area.

Stretch 8: River Road Stretch [MB_008RR]

The final surveyed stretch of the Mayes Brook is heavily canalised from the Roundabout Ditch inlet (Figure 4.19h) to its confluence with Barking Creek. Due to limited access this stretch was assessed using Google Earth images (accessed September 2009). The over-widened and over-deepened channel is fully reinforced with minimal in-channel vegetation. Riparian trees form a semi continuous line along the left bank between the channel and adjacent industrial estate. There is a large tidal flood sluice at the confluence with the River Roding at the downstream end of this stretch.

4.5.3 Thematic Classification and Stretch Habitat Quality Index results for the Mayes Brook catchment

This section provides assessments for surveyed stretches within the Mayes Brook catchment: using the URS engineering types (Table 3.1), thematic classifications (Table 3.4) and SHQI scores (Table 3.5). The results of the URS analyses for the Mayes Brook catchment are also brought together in Table 4.7 at the end of this section.

4.5.3.1 Engineering types

Figure 4.20 summarises the planform, cross profile and level of reinforcement components of the surveyed stretches of the Mayes Brook. All surveyed stretches are either enlarged (over-deepened and/or over-widened) or re-sectioned (with a trapezoidal cross-section) and, with the exception of stretch 1, where the engineered channel follows a more sinuous planform (ME), all have straightened planforms (ST).

The levels of channel reinforcement were recorded as 'both banks only' in stretches (3-7) and 'full' for all other stretches. A reliable assessment of bed reinforcement was sometimes limited by in-channel vegetation, silt deposition or restricted access. At some stretches, visible deposits of gravel and silt sediments form the dominant channel substrate and so the level of reinforcement in these stretches is recorded as 'both banks only' as superficial sediments can provide important habitat opportunities in urban rivers. In other stretches (e.g. stretches 1, 2, and 8) bed reinforcement was visible and so 'full' reinforcement was recorded.

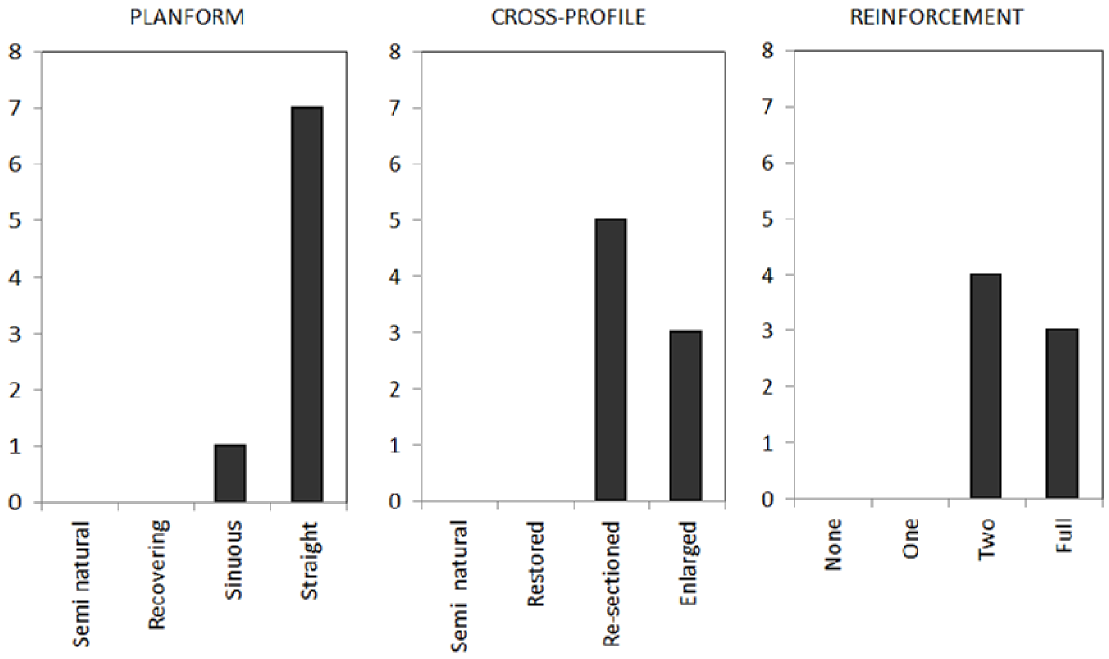


Figure 4.20 Bar charts summarising the frequency of planform, cross profile and reinforcement types recorded on the Mayes Brook

4.5.3.2 URS Thematic classification

A comparative overview of the URS Classification scores for each theme is provided by the bar chart in Figure 4.21. Further discussion of the individual classifications continues below.

(i) Materials

The materials classification derived from the URS aggregate indices reflects the type and mobility of natural and artificial materials making up the channel banks and bed (Table 3.4). In stretches 3 to 7, the banks included a variety of artificial 'immobile' materials ranging from full bank face protection (stretches 1, 5 to 7) consisting of solid concrete and brick (Figure 4.22) or 'open matrix'-type bricks, to concrete bank toe protection (stretches 2 to 4). In some locations, where banks were inaccessible or obscured by overhanging vegetation, in most cases materials or types of protection could be inferred from the nature of the marginal and riparian vegetation, overall channel engineering and the proximity of adjacent developments.

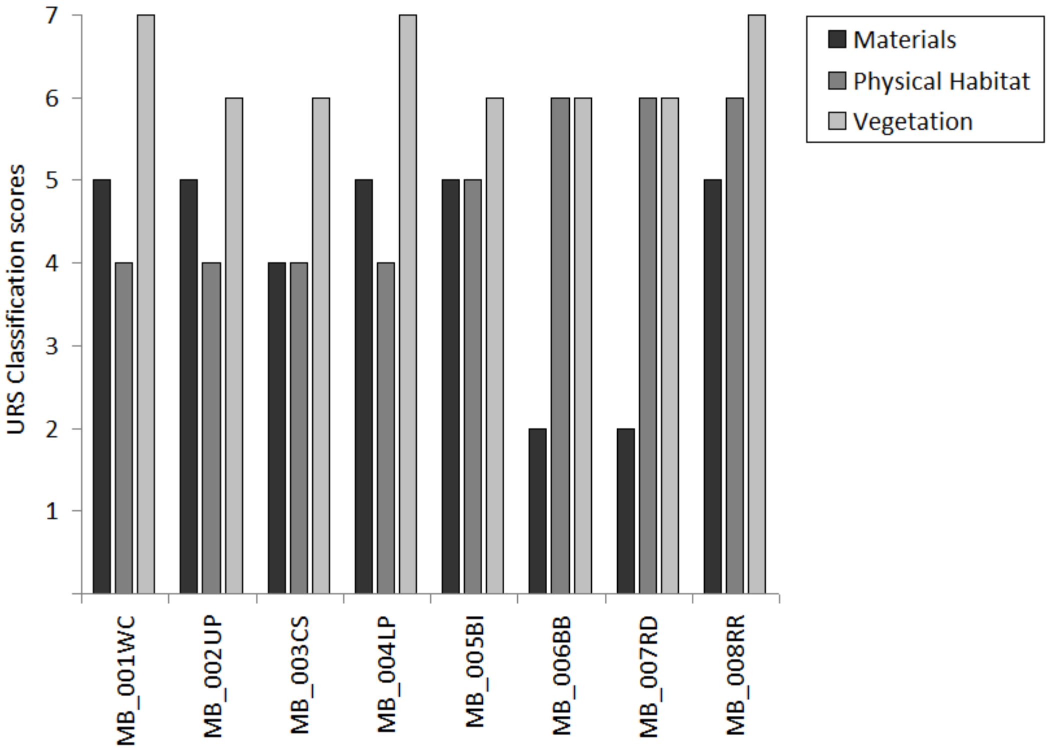


Figure 4.21 Bar chart illustrating the URS thematic class values for Bank / Bed Materials, Physical Habitat and Vegetation structure for the surveyed stretches of the Mayes Brook

Figure 4.22 View of Mayes Brook at Stretch 1 [MB_001WC] at the time of survey, showing full reinforcement of banks and bed during low or dry weather flow conditions

Where the channel bed was obscured due to depth and the bed substrate or protection types could not be confirmed, bed material was either recorded as ‘not visible’ or ‘silt’ if confirmed at channel margins. Along stretches 2-4 in Mayesbrook Park, fragmented bank toe and bed protection of conglomerated concrete was interspersed with overlying gravels and silt deposits creating a complex mix of materials. Where bed and bank protection appeared to pre-dominate at the reach scale the proportion of this was recorded along with the superficial materials and habitat features. The materials classifications derived from the URS indices for bank and bed materials are ‘Lightly Engineered’ (LE) for stretches 6 and 7 and ‘Heavily Engineered’ (HE) for stretches 1 to 5 and 8.

(ii) Physical Habitat

The physical habitat classification derived from the URS aggregate indices reflects bank profile characteristics and the diversity of flow types and in-stream habitat features such as (un)vegetated bars and pools (Table 3.4). The Mayes Brook stretches are all classified as ‘uniform’, with some being attributed to the uniform active (UA) class and some to the uniform moderately active (UM) or stable (US) classes (Figures 4.23a-d). Within Mayesbrook Park all stretches (1 to 4) are classified as Uniform Active. All of these stretches were dominated by glides but contained a variety of physical habitat diversity. The reinforced bed and banks along stretch 1 were in poor condition resulting in hydraulic complexity that had induced some variety in physical habitats, sufficient for a classification of Uniform Active (Figure 4.23a).

Diversity of flow types was slightly greater within stretches 1 to 3 than stretch 4, leading to an increase in the number of morphological habitats, including the presence of some small riffles (Figure 4.23b). Pool features were also recorded adjacent to active inlets, resulting from bed scour by flows from the inlets and the disintegration of channel bed reinforcement. The number of bars recorded was relatively low in stretches 1 and 4 in comparison with stretches 2 and 3.

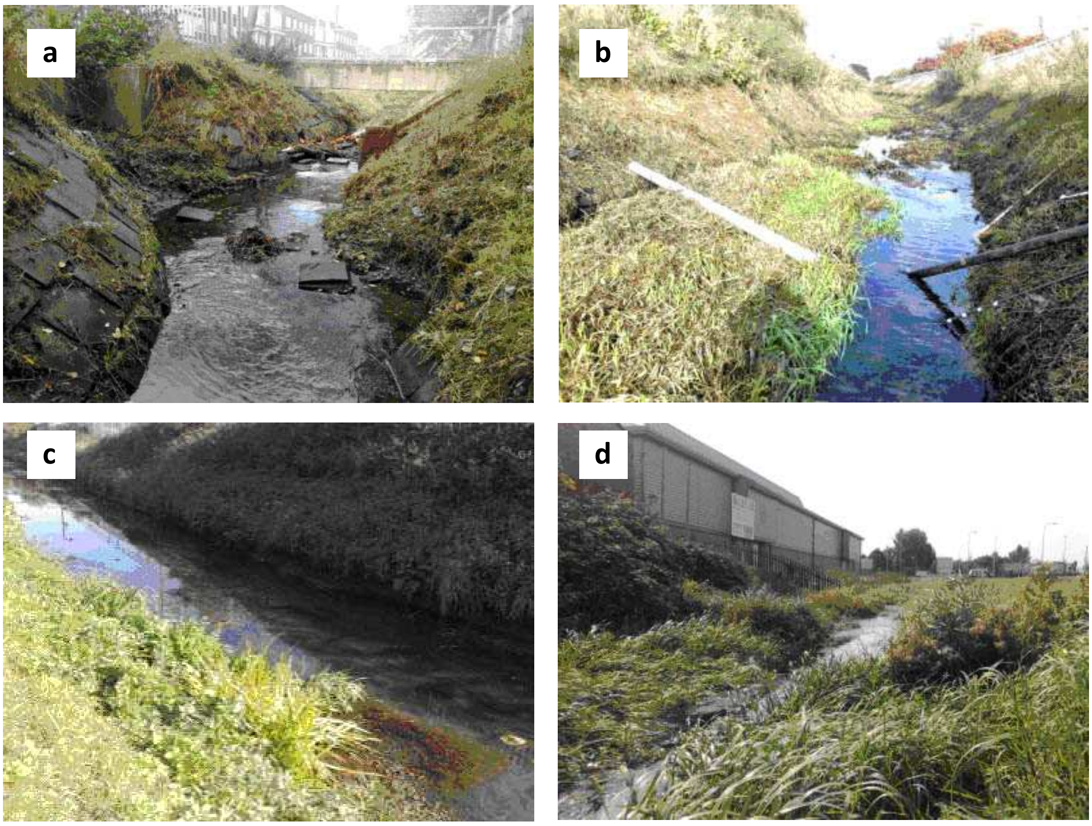


Figure 4.23 Views of the Mayes Brook channel in October 2009, during dry weather flow conditions representing a range of Physical Habitat types classified as: (a) Uniform Active at Stretch 1 [MB_001WC]; (b) Uniform Active (UA) at Stretch 2 [MB_002UP]; (c) Uniform Moderate (UM) at Stretch 5 [MB_005BI]; (d) Uniform Stable (US) at Stretch 6 [MB_006BB]

Altogether, the stretches within Mayesbrook Park featured between 7-10 different channel habitat types, with numerous vegetated side and mid-channel bars dominating stretches 2 and 3. Although glides were the dominant flow type, where the side bars narrowed the channel, some small riffle features had formed. A small chute flow was also present at the transition between stretches 1 and 2 where the level of the brook drops between differently engineered sections.

Downstream of the Rippleside Cemetery culvert, a change in the physical habitat of the brook was indicated by the presence of semi-continuous side bars along the right bank of stretch 5 (Figure 4.23c), and uniform smooth (glide) flows within the channel leading to a physical habitat classification of Uniform Moderate (UM). In stretch 6, substantial vegetated side bars were present both adjacent to and upstream of the flood storage area (Figure 4.23d); while in stretch 7 the channel was heavily choked with reeds. In most stretches smooth glide flows dominated, while in the choked sections flows were barely perceptible. The full bank and bed reinforcement and relatively higher flow velocities at stretch 8 prevented any channel adjustment or recovery through significant sediment deposition. Physical habitat was classified as Uniform Stable (US) at stretches 6, 7 and 8.

(iii) Vegetation Structure

The URS Vegetation Structure classification score and ranking is discriminated by the dominant vegetation type, the composition of bank top and face and tree cover (Table 3.4). The Mayes Brook, survey stretches were all classified as either Algal Channels (ALG) (stretches 1, 4 and 8) or Unvegetated Low Complexity (ULC).

Field observations at stretches 2, 3, 6 and 7, found the dominant in-channel vegetation type to be emergent reeds and sedges, with parts of the channel fully choked within stretches 3, 6 and 7. Despite the high cover of in-channel vegetation within several stretches, the dominance by algae at some stretches appears to override the complexity of the bank face and top and tree cover (Figure 4.24).

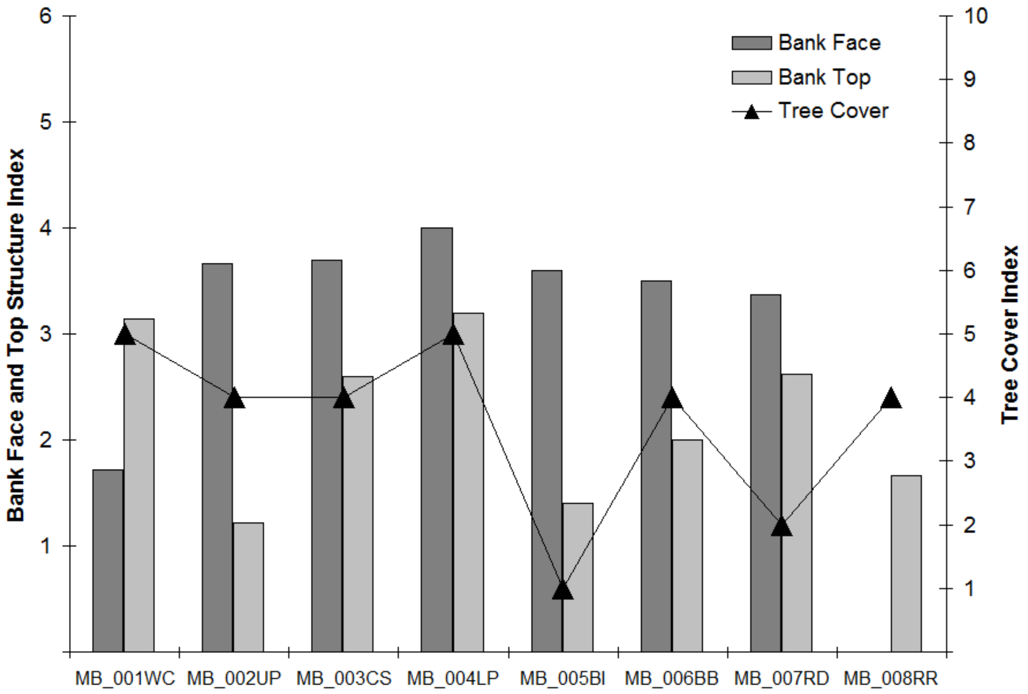


Figure 4.24 Comparison of index values for bank face and bank top structure; and tree cover at Mayes Brook URS stretches recorded during October 2009

Indices can also be derived from URS data that allow the structure of in-channel vegetation habitats and the diversity of macrophyte types to be characterised. Recorded data include percentage coverage and number of different aquatic vegetation types recorded at spot checks (with an option to record additional types observed between). The URS indices derived from these data are CountVeg (count of macrophyte types) and AveVeg (average percentage cover of macrophytes). Another index: DomVeg (dominant macrophyte type) is scored in relation to a gradient of flow resistance. Values of these indices for the Mayes Brook stretches are provided in Table 4.6 and the AveVeg scores (% macrophyte cover) are displayed in Figure 4.25 with channels classified as ‘Algal’ shown in black.

Table 4.6 Comparison of URS aggregated indices for macrophytes

Stretch ID	AveVeg (% cover)	CountVeg (no. types)	DomVeg (score reflects level of flow resistance)
MB_001WC	36	5	3
MB_002UP	66	5	10
MB_003CS	81	5	10
MB_004LP	19	5	3
MB_005BI	69	6	8
MB_006BB	76	6	10
MB_007RD	89	4	10
MB_008RR	27	1	3

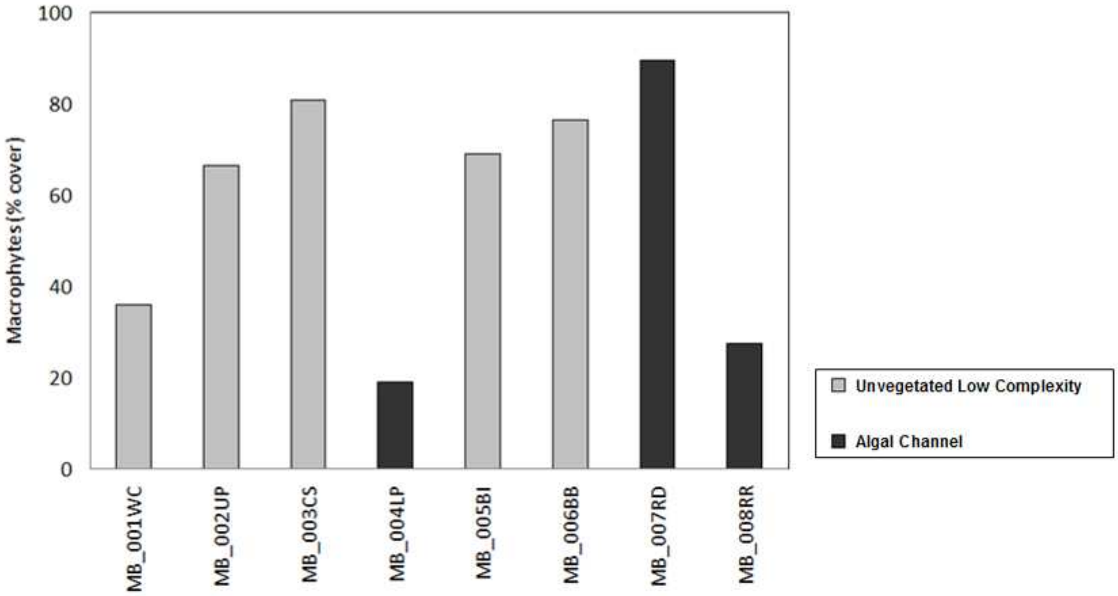


Figure 4.25 Bar chart comparing average percentage cover of macrophytes for Mayes Brook stretches and sorted by Vegetation Structure class type

These findings suggest that the Vegetation Structure Classification does not perform well for the Mayes Brook stretches as an indicator of in-channel vegetation structure. Consideration therefore needs to be given to whether the Vegetation Structure Classification needs revision or whether it would be more appropriate to develop two vegetation classifications for the riparian and in-channel vegetation respectively. Due to time constraints it has not been possible to investigate the development of the URS vegetation structure classification as part of this project; it is therefore recommended as a future research need.

Another element of the URS survey that provides important information on vegetation is the presence of nuisance species. On the Mayes Brook, frequent occurrences of Japanese knotweed were recorded at stretches 6 and 7 with occasional clumps at stretch 5. It is notable that no nuisance species were observed at stretches 1 to 4, upstream of the Rippleside Cemetery culvert and located adjacent to Mayesbrook Park suggesting that here channel fragmentation has had a beneficial effect in halting the spread of undesirable species. Again, the development of a ‘nuisance species’ index which specifically highlights the presence and type of invasive species in conjunction with bank materials and profiles represents an area of potential future research that would support practitioners in by targeting management efforts to control and reduce the risk of alien invasions.

Further information on land use captured by the URS may also contain further useful metrics for anthropogenic impacts as well as socio-economic indicators. These elements also represent potential areas for future research and development for the Urban River Survey.

4.5.3.3 The Stretch Habitat Quality Index (SHQI)

The three classifications of materials, physical habitat and vegetation are attributed scores that underpin estimation of the integrated SHQI (Tables 3.4 and 3.5). Table 4.7 summarises the URS thematic classifications for each stretch, illustrating the generally poor quality of all stretches through the combined SQHI scores (shown in Figure 4.14).

The combined SHQI scores provide a broad indicative overview of stretch habitat quality but lose much valuable detail about the habitat:engineering relationships and potential for rehabilitation. The following sections describe the more detailed outputs of the Principal Component Analysis and URS matrix in relation to the Mayes Brook catchment.

4.5.4 URS matrix results for the Mayes Brook catchment

The Principal Component Analysis described in section 4.3.1, also includes indices for the surveyed stretches of the Mayes Brook. The plotting positions of the surveyed stretches with respect to the first two PCs (Figure 4.26a) and the URS matrix (Figure 4.26b) reveal groupings in the stretches and a clear transition in bio-physical condition between the upstream and downstream stretches.

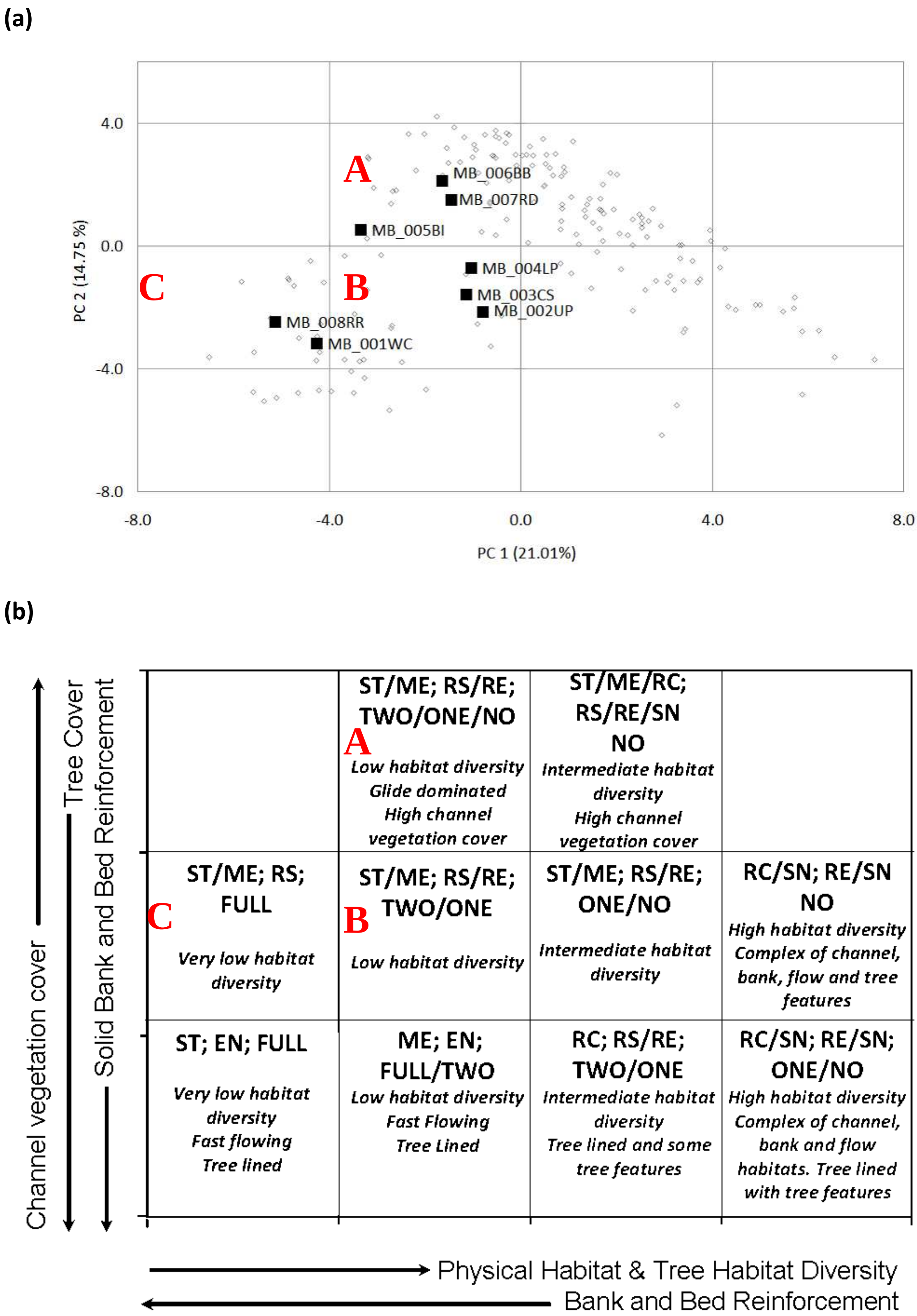
Stretches 1 and 8 are located close together towards the lower left of the Mayes brook stretches, indicating relatively lower scores on both PC1 and PC2 (Figure 4.26a). Located on the URS matrix in the area marked ‘C’ (Figure 4.26b), their channel characteristics are identified as: straight or sinuous; re-sectioned; with two banks or fully reinforced and very low habitat diversity.

The next cluster of sites includes the adjacent stretches 2, 3 and 4 within Mayesbrook Park (Upper Park, Case Study and Lower Park stretches). These stretches are closely grouped within the area marked ‘B’ on the URS matrix (Figures 4.26 a and b). Here channel characteristics are described as: straight or sinuous; re-sectioned or restored channels; with one or both banks reinforced and low habitat diversity. It is likely that the position of these stretches towards the right of box ‘B’ reflects the presence of bank toe reinforcement rather than full bank protection, leaving the potential for some bank habitats and vegetation that may have improved their position on this habitat diversity gradient.

The final 3 stretches (5, 6 and 7) all occupy box ‘A’ on Figures 4.26 a and b, with channel characteristics defined by the URS matrix as: straight or sinuous; re-sectioned or restored; with no, one or two banks reinforced and low habitat diversity, dominated by glides and high in-channel vegetation cover. The location of these stretches within box ‘A’ reflects their lower levels of reinforcement, higher proportions of in-channel vegetation but relatively low habitat diversity in comparison with the other surveyed stretches. However there is a separation between stretch 5 and the other two stretches with respect to PC1, reflecting the higher levels of bank reinforcement and lower physical habitat diversity at stretch 5 in contrast to stretches 6 and 7.

Table 4.7 Summary of engineering types, URS Classification and SHQI scores recorded for Mayes brook stretches

	Stretch 1	**Stretch 2**	**Stretch 3**	**Stretch 4**	**Stretch 5**	**Stretch 6**	**Stretch 7**	**Stretch 8**
Stretch ID	MB_001WC	MB_002UP	MB_003CS	MB_004LP	MB_005BI	MB_006BB	MB_007RD	MB_008RR
Stretch name	Waterside Close	Upper Park Reach	Case study reach	Lower Park Reach	Barking Industrial Est.	Barking Bypass	Roundabout Ditch	River Road
Stretch length (m)	300	400	500	500	500	500	500	250
Engineering Type								
Engineering: Planform/ Cross-profile	Sinuous/ Re-sectioned	Straight/ Re-sectioned	Straight/ Re-sectioned	Straight/ Re-sectioned	Straight/ Re-sectioned	Straight/ Enlarged	Straight/ Enlarged	Straight/ Enlarged
Level of Reinforcement	5	5	4	4	4	4	4	5
URS Classification								
Materials class	Highly Engineered	Highly Engineered	Highly Engineered	Highly Engineered	Highly Engineered	Lightly Engineered	Lightly Engineered	Highly Engineered
Materials class score	5	5	5	5	5	2	2	5
Physical Habitat class	Uniform Active	Uniform Active	Uniform Active	Uniform Active	Uniform Moderate	Uniform Stable	Uniform Stable	Uniform Stable
Physical Habitat class score	4	4	4	4	5	6	6	6
Vegetation class	Algal Channel	Unvegetated Low Complexity	Unvegetated Low Complexity	Algal Channel	Unvegetated Low Complexity	Unvegetated Low Complexity	Unvegetated Low Complexity	Algal Channel
Vegetation class score	7	6	6	7	6	6	6	7
Stretch Habitat Quality Index	16	15	15	16	16	14	14	18
SHQI class	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Very Poor



	ST/ME; RS/RE; TWO/ONE/NO A *Low habitat diversity* *Glide dominated* *High channel vegetation cover*	**ST/ME/RC; RS/RE/SN NO** *Intermediate habitat diversity* *High channel vegetation cover*	
ST/ME; RS; FULL C *Very low habitat diversity*	B **ST/ME; RS/RE; TWO/ONE** *Low habitat diversity*	**ST/ME; RS/RE; ONE/NO** *Intermediate habitat diversity*	**RC/SN; RE/SN NO** *High habitat diversity* *Complex of channel, bank, flow and tree features*
ST; EN; FULL *Very low habitat diversity* *Fast flowing* *Tree lined*	**ME; EN; FULL/TWO** *Low habitat diversity* *Fast Flowing* *Tree Lined*	**RC; RS/RE; TWO/ONE** *Intermediate habitat diversity* *Tree lined and some tree features*	**RC/SN; RE/SN; ONE/NO** *High habitat diversity* *Complex of channel, bank and flow habitats. Tree lined with tree features*

Figure 4.26 The plotting positions of the Mayes Brook stretches with respect to (a) the first two principal components and (b) the URS matrix

4.5.5 Conclusions of URS-based catchment scale investigation of the Mayes Brook

The overall results of the URS assessment indicate distinct groupings in the characteristics of the eight Mayes Brook stretches. This is reflected in both the URS classification results and URS matrix. Step changes in the character of the brook between the most upstream stretch (1), the stretches within Mayesbrook Park (2 to 4) and the downstream stretches between Mayesbrook Park and Ripple Rd (5 to 7), are indicated by the distribution of the sites on the scatter plot and URS matrix (Figure 4.26), reflecting different reach 'units' and the longitudinal fragmentation of the brook. The exception to this downstream pattern occurs at stretch 8 due to channel engineering associated with flood risk management and the tidal sluice gates at the confluence with Barking Creek.

The SHQI scores indicate that all surveyed stretches within the Mayesbrook catchment are of 'poor' or 'very poor' habitat quality with the poorest quality stretches located immediately upstream and downstream of the culverted sections (stretches 1, 4 and 5), and the lowest canalised stretch upstream of the tidal sluice (stretch 8). From their locations on the PCA scatter plot, particularly with respect to PC1 (Figure 4.26a), stretches 1, 5 and 8 are indicated as being the most heavily reinforced with the lowest habitat diversity and would therefore be likely to benefit the most from rehabilitation measures to reverse these impacts. However, at stretches 5 and 8, this is unlikely to be a feasible option due to flood defence requirements.

In particular, the URS results suggest that stretch 1 could benefit substantially from rehabilitation measures. For example, removing the hard bank protection and reducing the tree cover would allow macrophytes to establish and support a greater biodiversity. The results of invertebrate surveys carried out by the EA indicate a relatively high BMWP score at this location (EA, 2010a). Stretch 1 therefore provides the greatest opportunity for gain from rehabilitation among these most heavily degraded stretches. The location of this reach alongside an area of restricted access amenity grassland also provides space for rehabilitation measures.

The Case Study stretch (3) within Mayesbrook Park compares favourably with the worst stretch (1). However, there are still significant opportunities for biophysical improvements of all of the stretches adjacent to the park (1 to 4). Considerable benefits could be achieved through the removal of immobile bank and bed materials to allow morphological adjustment and increased habitat diversity within the channel. Additional habitat and ecological benefits would be gained by reconnecting the channel with the floodplain and grading the bank more softly towards the open parkland where space and infrastructure permits this.

The downstream stretches (6 and 7) at Barking Bypass and the Roundabout Ditch, although classified as having ‘poor’ stretch habitat quality, do sustain a more diverse range of habitats than the upstream stretches (in terms of side bars and in-channel vegetation) which is clearly reflected within their plotting positions in Figure 4.26a and b. While biophysical diversity and dynamism are constrained in these locations due to the over-enlarged channel forms and bank reinforcements, required for flood defence purposes, some channel recovery has occurred, especially at stretch 6, through channel narrowing by the side bars and this could be further encouraged if flood defences are not compromised. At the Roundabout Ditch (stretch 7), the low flows are insufficient to maintain the channel capacity and therefore it is likely that some removal of the accumulated silt along this stretch might help to increase biophysical diversity as well as conveyance.

The outputs of the URS catchment scale assessment for Mayes Brook demonstrate that this methodology can provide evidence which differentiates between the different integrated engineering:habitat qualities of river stretches within an urban catchment. Some modification of the Vegetation Structure classification would help to make this more informative and easier for non-river experts to interpret.

Potential for further development of a more sensitive vegetation classification and additional indices for nuisance species and land use exists and further research in this area is recommended.

4.6 Case Study Restoration timeline: URS assessments

The case studies chosen for this research project were selected on the basis of their restoration histories, to enable an investigation of changes over time in: (i) urban river restoration approaches and (ii) the post-project recovery of restored urban rivers. The primary case study at Mayesbrook Park represents a pre-restoration stretch of urban river (the Mayes Brook), while three other stretches located on the rivers Ravensboune, Brent and Pool, represent restored stretches at different stages of recovery following restoration works carried out one, five and fifteen years ago, respectively (section 3.2.3).

One aim of this research is to investigate the evidence for geomorphological and vegetation responses to river restoration within the river channel and riparian zone of the case study sites in the context of the chronology and style of restoration. Further investigation of the case study management and restoration histories is provided in Chapter 6 (section 6.2)

The paired comparisons of unrestored and restored stretches for the case study sites on the rivers Brent and Ravensbourne (section 4.4) provided considerable evidence for the bio-physical changes that have occurred within each river since the completion of the restoration works. Within this section, the plotting positions of all four case studies are examined with respect to the PC1:PC2 scatter plot and are discussed in relation to the individual restoration histories.

4.6.1 Interpretation of the bio-physical condition of the case study stretches using the URS matrix

URS surveys were conducted on the four case study stretches during the summer of 2009 and the results included in the Principal Component Analysis of URS aggregate indices (section 4.3.1). The plotting positions of the individual stretches with respect to PC1 and PC2 (Figure 4.27), provide a rapid overview of the different type of integrated engineering:habitat condition present at each stretch and indicate considerable bio-physical differences between the sites.

4.6.1.1 Mayes Brook at Mayesbrook Park

A detailed description and discussion of the characteristics of the pre-restoration stretch of the Mayes Brook (located centrally within the plot, Figure 4.27) have been presented in section 4.5, in relation to the catchment scale investigation. The URS assessment provides evidence that the poor habitat condition (SHQI score = 15) of this stretch is related to a high level of engineering (straightened, re-sectioned, both banks reinforced)

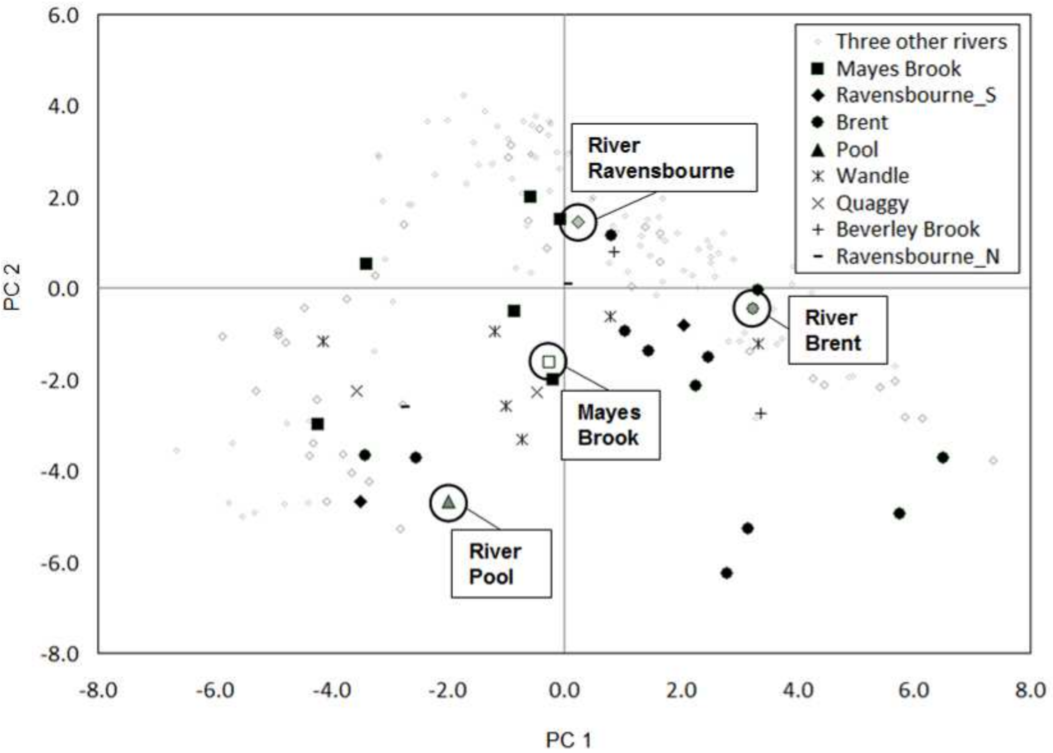


Figure 4.27 The plotting positions of the case study sites highlighted on the scatter plot of stretch scores on PC1 and PC2. (Case study stretches are labelled and match the symbol used for other stretches surveyed within the same catchment. The case study stretch symbols are shaded according to the length of time elapsed since restoration from dark (longest) to pale (shortest) with the unrestored Mayes Brook stretch unshaded)

and low habitat complexity. However the presence of bars, minor riffles, channel narrowing and macrophytes has created some physical habitat diversity within the channel, giving it an intermediate plotting position along PC1. Planned restoration works for this stretch include the creation of a new sinuous channel within the adjacent green space of Mayesbrook Park, where existing river terrace gravels will provide a natural sediment supply and facilitate the generation of physical habitat features. The creation of a channel similar to that of the restored Ravensbourne is likely to result in an increase in the scores for this stretch on PC1 and PC2. An early view of the restoration works are provided in Figure 4.28

REACH 3 BEFORE 06.05.11

REACH 3 DURING 12.07.11

Figure 4.28 An early view of the restoration earthworks at Mayesbrook Park compared to the pre-restoration landscape, July 2011. Source: Quartet Design

4.6.1.2 River Ravensbourne at Ladywell Fields - Completed: 2008

The plotting position of the Ravensbourne case study in Figure 4.27 reflects the lack of bank reinforcement and an intermediate level of habitat diversity with no tree features yet developed within the newly restored channel. The experimental nature of the works at Ladywell Fields included cutting a narrow channel into the pre-existing river terrace gravels with steep banks to facilitate natural adjustment and floodplain gravel recruitment.

> *'..as you've seen on the site, there are some vertical banks and some bank erosion taking place, we already knew that this was fine, that's what we wanted.'*
> (Conservation Team Leader, EA, 2010, Interview comments)

The restoration approach applied to this section of the river Ravensbourne was described by the EA lead manager as

> *'pioneering… there was potential to actually just adapt the channel to form itself '*
>
> (Conservation Team Leader, EA, 2010, Interview comments)

It is hypothesised that as the in-channel morphology and riparian vegetation develops, it is likely that the plotting position of this stretch in Figure 4.27 will migrate towards the lower right of the graph and the position of the Brent restored site. However, future evidence and site observations will be needed to support this hypothesis.

Figure 4.29 View of the newly restored Ravensbourne side channel at Ladywell Fields

4.6.1.3 River Brent at Tockyngton Park – Completed: 2004

In contrast to the immature condition of the Ravensbourne case study stretch, the restored Brent at Tockyngton Park has had five years for post-works recovery to occur. The restoration works at Tockyngton Park included a new sinuous channel. Due to the proximity of underground cables within the park, the project design needed to include some means of preventing excessive channel adjustment, whilst allowing for some naturalisation of the channel along the margins and riparian zone.

> ‘… *in terms of geomorphology, there’s a lot of bank protection because we had to get away with doing the scheme. Our engineers’ point of view was we had to over-design, over-engineer the channel, so it’s got rip rap in sections, some willow spiling....*
>
> (Environmental Monitoring Team Leader, EA, 2010, Interview comments)

Due to the moderate levels of mostly strategic reinforcement, over time, the restored channel has adjusted the original engineered planform through bank erosion and marginal deposition, creating new habitat features and enhancing physical diversity.

> *….. the river's actually re-adjusted itself, because it was a bit tight on that bend, so it is readjusting behind the reinforcements which would suggest that they're possibly not needed, because it hasn't been as active as we thought it was going to be.*
>
> *So one thing we have learned is just allow it a bit of space and accept that there will be some adjustment, but because it was one of the earlier schemes and because our engineers were very concerned, ….'*
>
> (Environmental Monitoring Team Leader, EA, 2010, Interview comments)

Figure 4.30 View of restored case study stretch on river Brent at Tockyngton Park: vertical eroding banks, mid-channel bar and riffle indicating morphological adjustments

The plotting position of the more mature restored Brent channel in Figure 4.27 reflects both the engineering:habitat character of the restoration works as well as the interactions and responses taking place during the adjustment period. The presence of maturing vegetation and habitat features are also clearly influencing the plotting position when compared to that of the Ladywell Fields stretch.

4.6.1.4 River Pool at Bell Green Gas Works – Completed: 1994

The plotting position of the final case study on the River Pool at Bell Green Gas Works in Figure 4.27 provides an interesting contrast to the other two restored sites. Prior to restoration, the river Pool was fully culverted due to the adjacent development of the gas works. As a result of land contamination risks the restoration of the river involved the creation of a new fully reinforced sinuous channel with concrete bed and banks to prevent the infiltration of toxic pollutants, such as hydrocarbons and heavy metals, into the aquatic ecosystem from the adjacent land. The restored channel is also enlarged to increase channel conveyance and avoid high river flows spilling into the adjacent site.

The restoration engineering included a concrete berm to create an artificial two-stage channel in the mid-section; and a series of concrete embayments filled with a coarse gravel substrate and planted to encourage macrophyte colonisation. Fifteen years after restoration works were completed the river has reworked much of the sediment introduced within the embayments, creating several artificial pools with gravel bars frequently located between the embayments (Figure 4.31). Deposition of fine sediments along the channel margins downstream of several of the artificial embayments has led to the development of natural berms and narrowing of the over-wide channel. Thus, despite the heavy engineering works, this stretch is demonstrating considerable channel recovery and functioning which is providing habitat opportunities for aquatic species.

Despite this, the plotting position of the stretch in Figure 4.27 remains strongly influenced by the extensive channel reinforcement and enlargement, giving it a modest score with respect to PC1. Nevertheless, the presence of some mature riparian willows within the embayments provide some tree features to add to the sediment habitats discussed above, giving the stretch a higher score on PC1 than other fully lined, enlarged channels. This suggests that although the heavy engineering of the channel generates a modest score on PC1, the recovery of some habitats is having a weak positive influence on the plotting position.

Figure 4.31 Views of the restored Pool river at Bell Green Gas Works (completed in 1994), showing indications of bio-physical recovery within the fully lined, enlarged concrete channel.

4.6.2 Conclusions of case study restoration timeline investigations

The results of the URS Principal Component Analysis provide several valuable insights into the differences between the bio-physical condition in relation to the case study restoration histories.

Although the heavy engineering approach applied at the River Pool was primarily a water quality contamination risk prevention strategy, the overall design and concrete embayments clearly aim to create dictate and control where habitat should be located. The over-engineered and reinforced restoration works on the Pool, and to some extent the River Brent each provide examples of ‘technological fixes’ to landscape challenges and an engineering paradigm which seeks to control dynamic variables by using ‘hard’ reinforcements (Clifford, 2007). The continuing influence of the hard engineering on the Pool and the softer engineering on the Brent which has allowed a more ‘naturalised’ channel to develop, are each clearly expressed through the URS matrix analysis, represented by the plotting position of the restored case study sites.

In contrast to the ‘over-engineered’ approaches of the Pool and Brent restorations (England, EA, 2010, Interview comment), the more experimental approach taken with the Ravensbourne case study reflects the importance of taking a fluvial geomorphological approach to river restoration design (Gilvear, 1999). Although the greater degree of risk to infrastructure and necessary caution of the design engineers working on the Brent restoration must also be acknowledged.

The experimental nature of the Ravensbourne case study site partly reflects the fact that all river restoration works are specific to the unique circumstances of individual sites. Lessons learned through monitoring the outcomes on the Brent indicate the value of reducing the level of engineering where the risk is low and allowing more space for the river to function and to modify its own channel.

‘…so one of the lessons learned for the Mayes Brook is that we can allow a little more space and accept that it’s going to have a bit more..’
(Environmental Monitoring Team Leader, EA, 2010, Interview comments)

4.7 Ecosystem services assessment

In contrast to the Urban River Survey, another kind of integrated river assessment receiving much attention from water policy makers and river managers is the Ecosystem Services Assessment (ESA). The growing interest in the Ecosystem Approach (section 2.4) to managing the natural environment has been gaining momentum and is now the subject of many policy guidance documents both within the UK and internationally (Defra, 2007b, 2007c, 2011; TEEB, 2010a, 2010b; Ranganathan et al. 2008). In England and Wales, the development of an ecosystem approach to river management and ecosystem services assessment (ESA) of rivers has been taken up by the Environment Agency; in relation to (semi)-aquatic environments and biodiversity by Natural England; and within the recently published National Ecosystem Assessment, delivered by a wide range of academic and professional experts (UK NEA, 2011a, 2011b)

River focused ESA reports have to date focused upon rural examples (Everard, 2009, Everard and Jevons, 2010) however, a research opportunity to investigate the role of this alternative integrated form of assessment and knowledge exchange in relation to an urban river arose through the case study at Mayes Brook. The main findings of this assessment (Everard et al. 2011) are reported below.

4.7.1 An Ecosystem Services Assessment of the Mayes Brook Restoration in Mayesbrook Park, East London.

Following the method described in section 3.3, collaboration between Queen Mary, University of London and the Environment Agency provided a research opportunity to investigate the usefulness of the ESA approach in the context of the restoration project at Mayes Brook.

Full details of the ESA report outputs are provided in Appendix D with summary results shown in Table 4.8.

Table 4.8 Copy of summary results of the Mayes Brook at Mayesbrook Park ESA describing changes in ecosystem services arising from the Mayes Brook restoration. (Source: Everard et al. 2011)

Ecosystem service	**Annual benefit assessed** **Research gap/note**
Gross annual provisioning service benefits	**There is no increase to provisioning services**. This contrasts markedly with related rural case studies (Everard, 2009a and 2010; Everard *et al*., 2009; Everard and Jevons, 2010; Everard and Kataria, 2010), where impacts on farm profits significantly affect this service category. Some development options (reuse of trimmings for 'fibre and fuel') may potentially produce provisioning service benefits.
Gross annual regulatory service benefits	**Gross annual regulatory service benefits are approximately £28,000** (calculated total = £28,087) comprising climate regulation @ £13,000 + flood risk @ £10,000 + erosion @ £5,000. However, there will also be **'likely significant positive benefits'** for the regulation of air quality and microclimate. All of these benefits relate almost entirely to public health and risk management, showing the potential role of Mayesbrook Park to enhance the wellbeing of the neighbourhood.
Gross annual cultural service benefits	**Gross annual cultural service benefits are approximately £820,000** (calculated total = £820,169) comprising recreation and tourism @ £815,000 + educational value @ £5,000. However, the net uplift (via 'social relations') to **regional regeneration is assessed with a lifetime (100 year) benefit of @ £7,800,000** which will be factored into the final NPV calculation.
Gross annual supporting service benefits	**Gross annual supporting service benefits are approximately £31,000** (calculated total = £30,573) comprising nutrient cycling @ £21,000 + habitat for wildlife @ £10,000.
Total annual ecosystem services uplift across the four categories	**Gross annual ecosystem service benefits are approximately £880,000** (total = £878, 829 based on summing calculated values to avoid rounding errors) but there are also **'likely significant positive benefits'** for the regulation of air quality and microclimate as well as a (100-year) contribution to **regional regeneration of £7,800,000.**

4.7.2 Critical appraisal of an urban river ESA

The main challenges encountered in producing an urban river ESA are reflected in the differences in key findings of the Mayes Brook ESA report in comparison to earlier rural ESA reports. From such a comparison, it is immediately apparent that the primary differences relate to (i) the importance of social factors and *cultural* services provided by urban rivers to local communities, and (ii) the relative lack of *provisioning* services which provide the primary benefits for rural equivalents.

The complexity of the interactions between urban river environments, local communities and stakeholders presents a risk of under-accounting for services that are not readily monetised, such as the benefits to mental and physical health for urban dwellers. Other ecosystem services, such as the potential for uplift in property values, may also only benefit small groups of stakeholders. Some of the most significant benefits to urban communities are recognised as *regulating* or *supporting* services, such as atmospheric cooling or building ecological resilience to climate change, and are likely to amount to significant economic value (e.g. offsetting indirect costs to society such as medical or fuel bills). However, gathering evidence to monetise these services is beyond the scope of the current evaluation methodology. If an ESA approach is to provide evidence to support future urban river restoration projects, a clear set of metrics needs to be established and agreed. In the light of the levels of international interest in the ESA method, it is likely that this will be an area of increasing research in future years. In this context, the currently high levels of activity in exploring methods to evaluate the ecosystem services provided by trees in urban environments will provide much additional information to the assessment of riparian corridors e.g. iTree Tools online Benefit Calculator, developed by the USDA Forest Service, (www.itreetools.org/design.php; see also Forestry Research, 2011).

As for any integrated research project, it is important to have clear boundaries for delivery of the main outputs. The primary constraints on delivery for the Mayes Brook ESA were lack of budget and time constraints for the main authors (Everard, Gurnell and Shuker). The main findings of the Mayes Brook ESA were initially compiled over a period of four to six weeks during which evidence was gathered and the main calculations undertaken. Where insufficient data were available to make valid calculations, a gap or research opportunity was noted. During the process, every effort was made to clearly state all assumptions and inclusions to maintain transparency and to avoid double counting. Between completion of the first draft in 2010 and eventual publication in 2011, an extended period of review was undertaken by EA environmental economists (Watts and Giacomello) to ensure consistency and validity of the methods applied. These delays revealed the cautious approach of thee regulatory authority in authorising and publicising the outcomes of this prototype urban river ESA report, potentially reflecting the mixed responses of ecological scientists, and greater levels of uncertainty within an urban ESA process.

However, the significance of approaches such as ESA in crossing boundaries between disciplines and exchanging knowledge of ecosystem service benefits is closely associated with the use of a different type of (economic) language and interpretation of the urban environment, which extends to individuals who may not otherwise recognise or have the means to acknowledge the value of the natural environment. As such, ESA represents a vital tool for urban environmental managers as a mechanism for knowledge exchange and, in the absence of better evaluation mechanisms, a device to engage and support decision making rather than a prescriptive accounting methodology. The development of more reliable methods for monetising urban river ecosystem benefits plus alternative non-monetary accounting approaches remain clear areas of research need.

4.8 Conclusions on Integrated Assessments of Urban Rivers

Within the context of the policy drivers described in chapter 3, and most significantly the requirement to improve ecological potential in heavily modified water bodies under the Water Framework Directive, the main focus of this chapter has been upon the bio-physical assessment of habitat condition in urban rivers. The benefits and the capacity of the Urban River Survey (URS) methodology were explored, firstly to accurately represent changes in engineering:habitat condition and secondly to communicate these changes through the various URS indices and classifications and the results of principle component analysis illustrated by the URS matrix.

As a tool for the assessment of bio-physical habitat condition, the URS provides a wide range of semi-quantitative data from which specific indices can be used to explore specific geomorphological features at the meso-habitat scale. Although the survey is similar in scope to the River Habitat Survey (RHS), the greater variety of empirical outputs generated by the URS provide scope for users to interrogate the data for more explicit indicators of process as well as the broader classifications and the composite Stretch Habitat Quality Index.

The added value derived from the URS comes from the association of habitat data with the engineering type as the defining factor of the survey stretch. Whilst the importance of large scale catchment controls, such as underlying geology, slope and distance from source, upon habitat features is emphasised in hierarchical classifications (Frissell et al, 1986, Naiman et al, 1992), local scale variations in slope, channel and catchment modifications may also have an overriding influence in urban catchments (Robinson, 2003). Therefore, the significant influences of land development and channel engineering upon urban river habitat structure and condition at the reach scale (300-500m) are the main focus of the URS analytical output.

Interpretation of the resulting relationships between the engineering and habitat character is made by the interpretation of the first two principle components of a multivariate analysis and illustrated using the URS matrix (sections 4.4.2, 4.5.4 and 4.6.1). These results indicate a variety of types and potential trajectories of change associated with changes in engineering. The differences in plotting position demonstrated by the paired reaches on Figure 4.16 reflect the contrasting restoration approaches taken at each site and the degree of recovery following engineering works. The greater maturity of the post- river Brent post-restoration reach, was clearly demonstrated by the plotting position on the URS matrix, corresponding to a greater diversity of physical habitat, riparian and in-channel vegetation features. In the five intervening years since restoration was completed, a variety of flow stages and high flow or channel forming events are likely to have contributed to the habitat diversity represented within the URS outputs.

By comparison, the relatively immature restoration site on the river Ravensbourne, displays a very different character in relation to pre-restoration channel conditions. The physical character of this newly created channel, is considerably less diverse, with a fewer habitat and vegetation characteristics. In the one year since restoration was complete, the opportunities for channel forming flows to act upon the bed and banks were not only limited by time, but also by imperfect functioning of the flow diversion weir restricting the potential of fluvial geomorphological processes to occur within the new channel. Furthermore, by comparing the Mayes Brook data at the catchment scale (Figure 4.26), the emergence of clustered points upon the URS matrix, suggests potential typologies of engineering:habitat association, which may indicate scope for further investigation, As the URS database expands, the development of understanding of these engineering:habitat relationships in heavily modified rivers, might then underpin guidance for management interventions and allow further investigation of reach to catchment scale responses in relation to restoration activities.

The intimate relationship between geo- or hydro-morphology and ecology is tightly coupled at the meso-scale in relation to habitat patches, physical heterogeneity and dynamic processes which maintain structural and biological diversity, lateral connectivity and resilience. The data rich semi-quantitative character of the URS elevates the potential of this methodology to provide specific indicators which can be fitted to the needs of WFD assessment and monitoring of physical habitat condition. By identifying the specific bio-physical supporting factors for fluvial ecology, such as pools, riffles, vegetated and unvegetated bars and riparian connectivity, the URS data are ideally suited to being parameterised to meet WFD requirements. For example, by highlighting the distribution of tree feature and habitat counts across the PCA plot (Figures 4.9 and 4.10) it is clear that different habitat typologies demonstrate different distributions. Further investigation of the distribution of key attributes required by WFD is included as a research recommendation in Chapter 9.

The results of this research project indicate that a variety of indicators of bio-physical condition in heavily modified rivers can be effectively demonstrated through the full range of URS outputs. Within this suite of descriptive and analytical tools the URS matrix and related PC scores have a particularly significant potential alongside other visual media (i.e. maps and photographic evidence) as a vehicle for knowledge exchange across disciplinary boundaries within professional and wider societal contexts. Several recommendations for future research arise in relation to the potential development of key indices for vegetation, nuisance species and land use. Also further investigation into the development of a more sensitive classification method for vegetation structure is recommended.

The investigation of changes in restoration practices through the case study evidence demonstrates a clear shift in approach from engineering orientated ‘control’ to interventions increasingly described as ‘experimental’. Where space is available, by allowing the river to adjust and regain ‘naturalistic’ functioning, by restoring connectivity with floodplain sediment stores, new dynamic habitat features can be recreated within restored stretches. In addition, the development of the URS method and outputs for practitioner use also supports current environmental policy objectives by facilitating local decision making and knowledge exchange with stakeholders. These findings are developed further in the context of restoration planning and management in the next chapters.

Likewise, this research project has demonstrated the potential of the Ecosystem Services Assessment (ESA) method as an integrated assessment method that can engage and communicate across traditional disciplinary boundaries. Despite current gaps in knowledge, the ESA approach offers an opportunity to demonstrate and evaluate the numerous benefits of urban river restoration, and to express and communicate the societal gains (monetised or acknowledged where monetisation is not currently feasible) from the bio-physical (or otherwise e.g. bio-chemical, etc) and ecological recovery of semi-natural functioning within urban river systems.

Chapter 5: Results II – Policy context for urban river management

5.1 Introduction

This chapter sets the context for the next research component: approaches to planning and delivery practices of urban river restoration and management by examining environmental policy discourses relating to management and conservation of river environments. Beginning with a consideration of the challenges for integrated management of water bodies in London the first section (5.2) reviews a broad selection of post-millennium environmental policy relevant to urban river restoration projects.

Section 5.3 details an investigation into the discourses surrounding the introduction of the European Water Framework Directive (WFD, 2000/60/EC). This section reviews the delivery mechanisms (5.3.1) and governance context (5.3.2) of the WFD before looking in detail at the River Basin Management Plans (RBMP) (5.3.3) and the discourses arising from the consultation to the draft Plans (5.3.4), followed by a critique of the main issues arising (5.3.5).

Section 5.4 next provides a comparative investigation of other environmental legislation relevant to urban rivers, encompassing policy for the protection of habitats and biodiversity (5.4.1), flood risk management (5.4.2) and climate change adaptation (5.4.3).

Section 5.5 examines the significance of urban planning policy in terms of the national planning system (5.5.1), regional and local development plans (5.5.2). Finally, the current policy context is reviewed in relation to the Mayes Brook case study restoration project (5.5.3).

The last section (5.6) presents the conclusions of the review of policy and the challenges of policy integration in relation to urban river restoration and sustainable management.

There has been a remarkable transformation in guiding policy over the last 20 years, reflecting the evolution of understanding of natural systems and gradual uptake through governance mechanisms (section 2.3.1). The wide array of policy that now supports sustainable development and the ecosystem approach however, presents significant challenges for river managers and restoration practitioners seeking to deliver projects 'on the ground' . Planning integrated urban restoration projects requires consideration of or compliance with increasing numbers of plans and policy recommendations. In particular, the recent development of guidance associated with the Water Framework Directive (2000/60/EC) has led to a radical overhaul of approaches to water body assessment and management for river regulators and practitioners.

The extract from the Mayes Brook Restoration preliminary scoping document (EA, 2008) shown in Table 5.1 illustrates the tiers and extent of policy considered relevant to an urban river restoration and raises the question of how river practitioners can best manage and satisfy all the guidance for integrated projects.

5.2 Environmental policy and integrated approaches to urban river restoration

5.2.1 Integrated water body management: post-2000 European context

The substantive changes in water related policy since 1980s, during a period described by Allan (2005) as 'reflexive modernity' (2.3.1), represent an evolution of public and professional reactions and actions in response to the negative impacts of damaging human activities upon shared natural systems. Such reactions, which have eventually gained political attention and policy support, date back to Hardin's' Tragedy of the Commons' (1968) and continue to be reinterpreted in the literature. For example Lant's 'Tragedy of Ecosystem Services' (2008) portrays ecological decline as persistently linked to the continued overconsumption of common resources. The Water Framework Directive (WFD) is one example of many scientists' efforts to integrate their findings into policy and practice. After years of disjointed policy focusing on one or other aspect of water resource or contaminant management, environmental and water policy

Table 5.1 Plans and policies relating to the Mayes Brook Restoration scheme. Source: Mayes Brook Restoration: Preliminary Scoping Consultation Document (EA, 2008)

	Waste and Mineral plans, contaminated land, air and noise	**Water Resources**	**Ecology and Nature Conservation**	**Recreation and tourism**	**Landscape and visual amenity**	**Land use, built environment, socio economics. Traffic and transport**	**Cultural heritage**
International	EU Landfill Directive EU Air Quality Directive	EU Water Framework Directive; EU Flooding Directive	EU Habitats Directive; EU Birds Directive				
National	PPS 10, 23, 25 PPG 14, 24 EA vision: restored protected land with healthier soils	Defra: Making space for water PPS 25 EA Thames CAMS EA Thames CFMP EA: Limiting and adapting to climate change River Roding FRMS Bringing Rivers Back to Life: Strategy for Restoring Rivers in North London	Town and Country Planning Act (1981) as amended Countryside and Rights of Way Act. PPS 7, 9, 25 PPG 2, 17 EA Biodiversity Strategy and Action Plan (Thames region) EA Vision: An enhanced environment for wildlife EA coarse fishery strategy	PPG 7, 17 EA Vision: A better quality of life EA Initiative: Thames ahead EA/Sports Council: A recreational strategy for the River Thames	PPS 1, 7 PPG 2, 17	PPS 1, 3, 6, 7 PPG 2, 13, 17	PPS 7 PPG 15, 16
Regional	GLA: London Plan & sub regional development frameworks London Biodiversity Action Plan North London River Restoration Strategy / London River Action Plan (to be launched in January 2009) London Climate Change Adaptation Strategy East London Green Grid						
Local	Local Biodiversity Action Plan for Barking and Dagenham Barking and Dagenham Unitary Development Plan (to be replaced by the Barking and Dagenham Local Development Framework Core Strategy)						

now supports an integrated ‘ecosystems approach’ (Defra, 2007b, 2010a) that seeks to combine an ecologically focused assessment and classification approach within a sustainable water development delivery model.

Several key concepts touched upon in the Literature Review (Chapter 2), and rising in significance for urban river restoration projects are briefly reiterated in Box 5.1 below. These include Sustainable Development, Ecosystems Approach, Climate Change Adaptation and Subsidiarity. The Mayes Brook restoration scoping report (Table 5.1) demonstrates the extent of environmental legislation and policy considered by Environment Agency (EA) practitioners to have relevance to urban river restoration: ranging from European level to regional and local strategies and plans. These include policies relating to the natural environment: i.e. the protection and sustainable management of aquatic environments and urban greenspace; as well as others focusing on urban environmental planning and social sustainability.

5.2.2 Integrating the ‘blue ribbon’ and ‘green grid’ networks

The inclusion of such a wide range of policy: ranging from aquatic environmental protection to local development plans and climate change adaptation strategy within the Mayes Brook restoration scoping report (Table 5.1), reflects both the breadth of scope of urban river restoration and level of practitioner awareness. The document provides evidence of the EA, acting as lead technical managers, applying an integrated planning framework from the earliest stages of the project (in parallel with their existing advisory role on planning applications with regard to biodiversity and flood risk).

Further integrated examples of national ‘green infrastructure’ policy can be found concerning access to greenspace in towns and cities (Harrison et al, 1995; Natural England, 2010). However, inconsistencies and changes in emphasis are evident between publications (Table 5.2). A strong emphasis on water within the greenspace definition of 1995 has been lost within the 2010 definition despite strong associations being demonstrated in other similar policy.

BOX: 5.1 Key concepts for integrated water and river management

Sustainable Development

The International focus on Sustainable Development, presented through the World Commission on Environment and Development (WCED) report 'Our Common Future' by Gro Harlem Bruntland, (1987) and the subsequent Rio Earth Summit (1992) each raised awareness of the importance of integrated approaches to development which combine the 'three pillars' of the environment, society and economics. The commitments of International signatories at the 1992 Earth Summit to Agenda 21: the action plan for sustainable development, ensured the uptake of these principles at the highest policy levels (2.4).

Ecosystem Approach

The parallel embedding of the systems approach follows the evolution of concepts in environmental science and growth of the understanding of ecosystems and earth systems e.g. the Gaia Theory. An international endorsement of ecosystem approaches has rapidly followed the UNEP Millenium Ecosystem Assessment (MA, 2005a), in particular the uptake of the framework for Ecosystem Services Assessments by several nations including the US, Australia, South Africa and several European countries. In England, the high number of research programmes and policy in support of the Ecosystem Approach produced by Defra (2010a; 2011) provides a new perspective for environmental management and conservation. The recent publication of the UK National Ecosystem Assessment (2011a) and the uptake of ecosystem services assessments and related research across the UK provide strong indicators of the shift in emphasis for practitioners and industry as they keep up with this rapidly changing policy area.

Landscape focus

One manifestation of this new era of 'greener politics' has been a multitude of statutory and voluntary mechanisms and measures designed to mitigate the environmental deterioration of both rural and urban landscapes. Indeed a new focus upon 'Landscape' strategies is currently at the leading edge of environmental policy delivery e.g. 2011 Landscape awards etc (e.g. from the Heritage Lottery Fund).

Adaptation to Climate Change

Further important discourses affecting environmental consciousness and policy within the late 20th century have focused around climate change in relation to human causes and responses to this phenomenon. International agreements to manage greenhouse gas emissions have been accompanied by policies to encourage mitigation and adaptation to changing climatic conditions. In urban environments, strategies include reduced maintenance of urban grasslands to provide more biodiverse habitat variety whilst cutting carbon emissions, and urban greening initiatives: to both cool urban heat islands and provide more opportunities for species resilience through an increased green infrastructure e.g. East London Green Grid (ELGG).

Subsidiarity and Localism

The concept of subsidiarity whereby decisions are made at the lowest level or tier of power and as close as possible to where the actions will be taken was first popularised by Schumacher (1973), has been reinforced through the principles of Sustainable Development, the Bruntland Report , 1987 and the Rio Earth Summit in 1992. Subsidiarity is also a broader principle of EU governance e.g. Lisbon Treaty (Kurpas, 2007) and is currently taking centre stage within the latest political concept of 'Big Society' and has been formalised through the Localism Bill, 2010.

Table 5.2 Definitions of greenspace in green infrastructure policy documents in Harrison et al. 1995 and Natural England, 2010

Document **(Year of publication)**	**Definition of Greenspace**
Accessible natural greenspace in towns and cities. A review of appropriate size and distance criteria. No. 153 - English Nature Research Reports (Harrison et al. 1995)	*'natural greenspace is defined as:* *'Land, water and geological features which have been naturally colonised by plants and animals and which are accessible on foot to large numbers of residents'.'* (p. 1)
Nature Nearby' Accessible Natural Greenspace Guidance. Natural England Report No. 265 (Natural England, 2010)	'The definition of green infrastructure, approved by the Natural England Board, is: *"A strategically planned and delivered network comprising the broadest range of high quality green spaces and other environmental features, designed and managed as a multifunctional resource, capable of delivering those ecological services and quality of life benefits required by the communities it serves and needed to underpin sustainability. Its design and management should also respect and enhance the character and distinctiveness of an area with regard to habitats and landscape types."'* (in text p.36; in list of definitions p. 8)

The focus on access to 'green' space in the 2010 policy is further emphasized by the accompanying figure (reproduced in Figure 5.1) which presents 'Water (Blue Space)' as a non-accessible entity, and also fails to associate rivers with 'Corridors and links'. These examples suggest that these kinds of 'missing links' between the terrestrial and aquatic environments demonstrated within some policy documents may be related to the focus of the author rather than current trends when such obvious connections are overlooked. The inclusion of the Access to Natural Greenspace Standards (ANGSt) within Natural England Report No. 265 and the limited definition provided for greenspace, suggests that an opportunity for integration has been overlooked and is not in line with previous policy of 1995 or the London Plan (GLA, 2011).

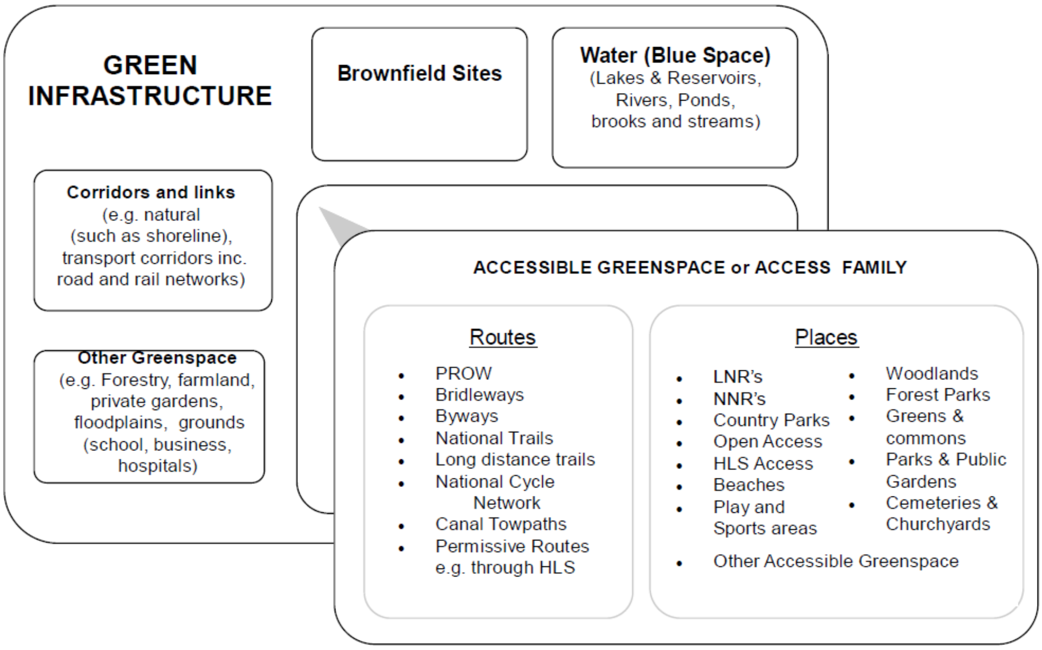


Figure 5.1 Depiction of Accessible greenspace within the wider Green infrastructure as defined by NE Report No.265: Nature Nearby - Accessible Natural Greenspace Guidance

5.3 EU Water Framework Directive (2000/60/EC)

The EU Water Framework Directive (EC, 2000) represents a significant and unprecedented piece of integrated water legislation covering surface waters, transitional waters (estuaries), coastal waters and groundwater bodies. The Directive provides a new approach to managing water bodies in relation to their ecology. The classification of ecological status or potential, is based specifically upon the condition of biological elements (for rivers: aquatic flora, benthic invertebrate fauna and fish fauna), and also upon the condition of the supporting hydro-morphological, chemical and physico-chemical elements (Annex V 1.1.1 p.34). The purpose of the Directive is primarily to prevent deterioration, protect and enhance the status of aquatic ecosystems; promote sustainable water use; reduce discharges and pollution, and contribute to mitigating the effects of drought and floods (Art 1(a-e)). This marks a major change from previous legislation which was focused upon water quality or quantity determined in relation to human or individual species' or habitat needs (e.g. Dangerous Substances directive, 76/464/EEC, and Freshwater Fish Directive 2006/44/EC, both due to be repealed in 2013).

A key aspiration of the WFD is the integrated, long term protection and sustainable use of water resources. Taking an integrated approach is explicitly prescribed in relation to groundwater (EC, 2000, para 7); water policy (ibid, para 9); pollution prevention and control (ibid, article 10(2c); and the development of an integrated programme of measures to achieve the objectives of good water status (ibid, para. 26). The Directive also highlights the need for even more joined-up water policy.

> *'Further integration of protection and sustainable management of water into other community police areas such as energy, transport, agriculture, fisheries, regional policy and tourism is necessary. This directive should provide a basis for a continued dialogue and for the development of strategies towards a further integration of policy areas* (EC, 2000, para. 16)

5.3.1 WFD delivery mechanisms

After coming into force in 2000, the transposition of the WFD requirements into national legislation by 2003 was the first requirement for Member States. Within England and Wales, this was enacted via the Water Environment (Water Framework Directive) Regulations 2003 by the Department of Environment, Food and Rural Affairs (Defra)[3]. The Regulations describe how the WFD is to be delivered, detailing the responsibilities of the 'competent authority' (Environment Agency) and the 'appropriate authority' (Secretary of State, Welsh Assembly or jointly) in relation to key deliverables required by the WFD, alongside the delivery timetable (Table 5.3). The Regulations define the boundaries of the ten River Basin Districts plus details of parties to whom the directive is considered to be relevant.

The WFD Articles and Annexes detail the key requirements for implementation (Box 5.2). Their content includes the definitions for 'high', 'good' and 'moderate' status for the primary ecological indicators (Annex V p.38-51); the design and reporting requirements for environmental surveillance, operational and investigative monitoring (Annex V p.53) plus detailed requirements for the content of the draft, final and updated versions of the River Basin Management Plans (Article 13; Annex VII). For each

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[3] Separate versions were published for England and Wales, Northern Ireland and the transboundary Northumbria River Basin District. The transposition for Scotland was administered through the Water Environment and Water Services (Scotland) Act 2003.

significant output or product of the WFD process (Table 5.3), the requirements for public information and consultation are also specified (Article 14).

Table 5.3 WFD Timetable for delivery. (Source: http://www.euwfd.com/html)

Year	Action	Article	
2000	Water Framework Directive entered into force	22; 25	3 years for Member States to prepare
2003	Transpose requirements to national legislation; Define River Basin Districts and Authorities	23; 3	
2004	Characterise river basins: pressures, impact and economic analysis	5	6 years to analyse issues and prepare the River Basin Management Plans
2005	Identify significant trends in groundwater pollution	17	
2006	Establish environmental monitoring programmes; Publish and consult on a work programme for the production of the first River Basin Management Plans (RBMPs); Establish environmental quality standards for surface water	8; 14; 16	
2007	Report monitoring programmes to the EC; Publish and consult on summary of significant water management issues (SWMI) for each River Basin District	14	
2008	Publish and consult on drafts of the RBMPs	14	
2009	Publish the first RBMP for each River Basin District; Establish programmes of measures (PoMs) in each River Basin District in order to deliver environmental objectives	13; 11	3 years to put programmes of measures in place
2010	Report RBMPs, including PoMs to the EC; Introduce water pricing policies	9	
2012	Ensure all POMs are fully operational; Report progress in implementing the first RBMPs	11; 15	
2013	Review progress of the first RBMP cycle		3 years to achieve specified objectives
2015	Main environmental objectives specified in the first RBMPs met?	4	
2015	Review and update first RBMPs	13, 14, 15	Further 6 years' planning, consultation and implementation cycles
2021	Main environmental objectives specified in the second RBMPs met?; Review and update second RBMPs	4; 13;14; 15	
2027	Main environmental objectives specified in the third RBMPs met?; Review and update third RBMPs	4; 13; 14; 15	

Box 5.2 WFD Contents: Articles and Annexes

Article	
1	Purpose
2	Definitions
3	Coordination of administrative arrangements within RBDs
4	Environmental Objectives *
5	Characteristics of the RBD, review of the environmental impact of human activity and economic analysis of water use**
6	Register of Protected areas
7	Waters used for the abstraction of drinking water
8	Monitoring of surface water status, groundwater status and protected areas
9	Recovery of costs for water services
10	The combined approach for point and diffuse sources
11	Programme of Measures***
12	Issues which cannot be dealt with at Member State level
13	River basin management plans****
14	Public information and consultation*
15	Reporting
16	Strategies against pollution of water
17	Strategies to prevent and control pollution of groundwater
18	Commission report
19	Plans for future Community measures
20	Technical adaptations to the Directive
21	Regulatory committee
22	Repeals and transitional provisions
23	Penalties
24	Implementation
25	Entry into Force
26	Addressees
Annexes	
I	Information required for the list of competent authorities
II	Characterisation of surface water body types; identification of pressures; assessment of impact; characterisation of ground waters; assessment of impacts.
III	Economic analysis
IV	Protected areas registration
V	Classification of status; definitions of surface water ecological quality elements; monitoring of ecological and chemical status
VI	Lists of measures to be included within the programmes of measures
VII	River Basin Management Plans
VIII	Indicative list of the main pollutants
IX	Emission limit values and environmental quality standards
X	Priority substances
XI	Maps of Ecoregion systems

5.3.2 Governance context of the WFD

The language and principles of the WFD clearly reflect those of sustainable development (environmental, economic and social integration) and subsidiarity (Box 5.3). The specific requirement that decisions affecting water bodies should be made '*close to the location where water is affected or used*' (EC 2000, para. 13) prioritises the role of public and stakeholder consultation at key stages of the WFD process. A review of the key stages of implementation indicates the level at which water bodies are affected (Table 5.4). While some processes, such as water body characterisation and objective setting clearly require detailed technical knowledge at the local level, other stages (economic analysis, programme of measures) have aimed for a single or combined 'top down' analysis based upon existing information (Defra, 2007d).

Box 5.3 Summary of Key WFD Principles

(Summarised from 2000/60/EC paragraphs 11 & 13)

(i) the preservation, protection and improvement of the quality of the environment;

(ii) prudent and rational use of natural resources based on the precautionary principle;

(iii) preventative action whereby environmental damage should be rectified at source as a priority;

Table 5.4 Key stages within the WFD process, reporting level and scale of information required.

Stage	**Individual water body (Local)**	**River Basin District (Regional)**	**National**
Water body characterisation	✓		
Environmental objective setting	✓		
Register of Protected Areas	✓		
Identification of Significant Water Pressures		✓	
Programmes of Measures	✓	✓	✓
Economic analysis of water use		✓	✓
Extensions or exemptions (derogations) – due to disproportionate cost or technical unfeasibility	✓		
River basin management plan (RBMP) development	✓	✓	

Throughout the RBMP preparation stages (2004-8) communication with the representatives of key stakeholder groups, led by the EA, has been coordinated through National and Regional (RBD) level Liaison Panels. Each panel includes a single representative for the main sectors affected: water industry, ports, local business and industry, farming, regional and local government, recreation, fisheries, environmental NGOs. For each consultation stage, a specified list of consultees determined by Defra is also included in the 2003 transposing regulations and the consultation documents are published via the internet. The commissioning of the EA WFD Business and Industry Engagement Strategy (Entec, 2008) indicates the value placed upon increasing the involvement of the private sector in environmental initiatives, particularly in relation to the delivery of non-statutory measures.

Following introduction of the WFD, a significant volume of supporting policy and guidance material, produced at both European and national levels, provides online assistance to competent authorities and co-deliverers in the UK (Table 5.5). As a new approach to multi-level environmental governance, the WFD is providing a testing ground for a more process-based approach which will develop through iteration, review and consultation. The approach set by the WFD, to bring decision making down to the lowest tier, presents enormous challenges in terms of information distribution and knowledge requirements in relation to complex technical issues. This also raises questions about whether WFD delivery can deal effectively with the practical realities of managing and integrating both the ‘top down’ and ‘bottom up’ processes the Directive details.

5.3.2.1 Urban and social context for WFD delivery

An integrated catchment perspective for urban rivers requires consideration of compound impacts of society upon aquatic ecosystems, including land use and human activities in densely populated areas. The increasing popularity of the term ‘river health’ to communicate the outputs of ecosystem quality assessments is an example of the use of less ‘scientific’ language used to integrate and engage society into aquatic environmental management (Norris and Thoms, 1999; Boulton et al. 1999; Zhao and Yang, 2009). While WFD references to ‘ecological status’ (or ‘potential’) communicate the new priorities for an ecological approach and mirror other Defra policy, ecosystems terminology may continue to present a linguistic and conceptual barrier to non-river or environmental experts with an interest in river quality (Everard, 2011), especially in urban environments where the implementation of WFD measures such as restoration may potentially deliver the widest benefits.

Table 5.5 WFD supporting policy and guidance

Policy instrument	**Level**	**Role**
Common Implementation Strategy (CIS)	European	To coordinate and harmonise implementation across the EU. To test the Directive in various pilot river basins across Member States, including the Ribble catchment in the UK (2003). Pilot led to first Integrated Catchment Management Plan in UK http://ec.europa.eu/environment/water/index_en.htm.
WFD-UK Technical Advisory Group (UKTAG)	UK	A partnership of UK environmental and conservation agencies managed by the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) and chaired by the Environment Agency. to provide technical advice to UK administrative, non-governmental organisations and key stakeholders; WFD specific research projects by SNIFFER are published in public domain at www.sniffer.org.uk/; www.wfduk.org
WFD Information Centre	EU / UK	Provided by the independent charity the Foundation for Water Research (www.euwfd.com).
Defra: River Basin Planning Guidance	UK	To support development of WFD reports undertaken by Defra: http://www.defra.gov.uk/environment/quality/water/wfd/index.htm

The integration of the principles of subsidiarity and participation within the WFD (EC, 2000, para 18) mirror the new approaches to governance and the devolution of decision making to the lowest tier (Bogdanor, 2008). An investigation into the partnerships associated with urban river restoration projects in London (1980s to present) reported in Chapter 6 (section 6.1), provides insights into the networks of organisations that form around such projects. Evidence from the individual case studies (section 6.2 and Chapter 7) provides further opportunity to investigate the social dimensions of urban river restoration planning and delivery, and the degree to which complementary or competing interests of partner organisations can lead to cohesion or fragmentation of the overall vision through the project planning processes.

5.3.2.2 Tensions and practical challenges arising through the implementation of WFD

The '*diversity of conditions and needs in the community'* recognised within the main text of the Directive (EC, 2000, para 13) clearly indicate an awareness of the potential for conflicts surrounding implementation of WFD measures. The specific requirement that '*Decisions should be taken as close as possible to the locations where water is affected or used'* (ibid) also immediately introduces more tension as water usage and affects may be in different locations. The challenges for the competent authorities in negotiating the delivery of actions to achieve the requirements of the WFD, to prevent deterioration, and to achieve good ecological conditions appear to be divided between the statutory obligations for industry and the largely voluntary actions.

The use of derogations (or defences for not achieving WFD requirements) also introduces scope for interpretation and divisions where different perspectives or priorities may exist for different stakeholders.

5.3.2.3 Scales of delivery and communication

The aspiration to achieve Good Ecological Status (GES) or Potential (GEP) across all water bodies and Member States is also fraught with practical challenges. At the highest level, the definitions of status levels for the classifying elements have required a massive amount of preparatory work to calibrate standards across Europe (Hering et al. 2010). The WFD administrative units, defined as river basin districts (RBDs) and covered by a single RB management plan, are based upon the watershed boundaries of major river catchments. In many cases, where a mismatch of natural environmental and political boundaries exists, the RBD boundaries cross administrative and, for some Member states, national boundaries thus requiring trans-national water management. The large scale of the RBDs inevitably results in a focus on 'top down' reporting and 'broad brush' approaches to problem solving which contradicts the stated principle of subsidiarity and has raised many concerns about the accuracy of characterisation and appropriateness of proposed solutions.

The substantive requirements for public engagement contained within the WFD regarding the preparation and updating of the River Basin Management Plans, are also complicated by the scale of information content that needs to be presented, and how the technical content should be presented to non-specialist stakeholders. This clearly has implications for communication and engagement to facilitate ‘lowest tier decision making’ at the local level.

5.3.3 River Basin Management Plans

The River Basin Management Plan (RBMP, or Plan) documents are central to the implementation of the WFD, providing a live management tool for each of the River Basin Districts. They represent the means by which the Competent Authority (the EA) aims to achieve Good Ecological Status (GES) or Potential (GEP, for water bodies classed as heavily modified). As a working document, each Plan provides details of the Programme of Measures or actions that will be carried out to achieve the environmental objectives stated for each water body within a RBD. During the six month consultation period (Dec 2008 – June 2009) draft copies of each RBMP (or dRBMP) were published and made publically available for comment via the Environment Agency website. Over 1200 responses were received for the combined 11 River Basin Districts, with 180 responses from Thames Region (Environment Agency, 2009b). Responses were provided by a wide range of organisations and individuals and were reviewed by the EA together with feedback from multiple workshops held in each River Basin District for stakeholders from different sectors and interest groups. Following consultation, the final Plans were sent to the Secretary of State in September 2009 for approval and published on 31st December 2009.

The Plan for each River Basin District follows a generic template containing a large amount of strategic information provided by the Environment Agency Head Office. Regional information relating to both environmental and social aspects of the Plan is inserted into the template in the relevant reporting sections (see Box 5.2 - Table of RBMP contents) e.g. details of Liaison Panel and consultees (in Annex L: Consultation and Engagement). Highly detailed environmental information is included at the catchment and water body scales, according to the reporting level required (Table 5.4), supported by a variety of maps and tables. Each Plan contains a summary of all the information used to assess ecological status/potential according to WFD definitions, including the River Basin Classification which incorporates the determination of protected, modified or artificial status; and Environmental Objectives or Alternative Objectives with associated derogations or defences as required.

As a working document, a key purpose of each RBMP (and therefore of most interest to stakeholders and river managers) is to outline the Programme of Measures, or actions that will be undertaken across a River Basin District. The level of detail provided varies according to the type of measure described and the means of delivery, ranging from national statutory measures down to local voluntary measures. The measures are divided into four categories (M1-M4) according to the level of decision making required and delivery mechanisms (Table 5.6).

Table 5.6 Definitions of WFD measures Source: Thames RBMP (Environment Agency, 2009a)

	Status	**Definition of Measure**
M1	Measures already happening.	Actions already agreed and funded, which may help to meet WFD objectives.
M2	New measures that will happen.	Actions that will happen irrespective of WFD (usually under other Directives) but which may help to meet WFD objectives. Mainly covers new actions for Directives on Freshwater Fish, Urban Waste Water Treatment, Habitats, Nitrates, current and revised Bathing Waters and Shellfish Waters.
M3	(a) New measures that may happen – national. (b) New measures that may happen – national, river basin district (RBD) targeted.	WFD measures that only require national decisions. Measures led nationally that require targeting at the water body or catchment scale.
M4	New measures that may happen – local, RBD agreed.	New measures specifically for WFD objectives that require no national decisions.

Within the draft plans the Programme of Measures is presented as three alternative scenarios (Table 5.7). These alternative scenarios each consist of a combination of national, regional and local statutory or voluntary measures that cover a range of potential actions with different levels of ‘certainty of delivery’ linked to mandatory status, funding or voluntary participation.

Table 5.7 Programmes of measures under three alternative scenarios, provided within the draft RBMPs (Source: Environment Agency, 2009a)

Scenario	Description
A	What is already happening and what will happen (M1, M2 and M3a measures and No Deterioration actions) ('Business as usual')
B	Additional actions that will happen if draft plan is approved (M3b and M4 measures) (Scenario A + additional measures that are certain)
C	Additional actions that could happen if we had more certainty (M3b and M4 measures) (Scenario B + extra measures that rely upon additional funding or voluntary participation)

For example, Table 5.8 below shows specific information relating to the Mayes Brook case study catchment as it appears under Scenario B within the Thames dRBMP. The Mayes Brook water body ('*Where it will happen'*) is specified within the combined catchments of the Roding, Beam and Ingrebourne ('*Catchment'*). The reason for the action ('*Pressure'*) is indicated as Physical Modification and the resulting measure ('*What will happen*') describes the investigation of channel restoration projects '*to improve flow regime and habitat creation*' (Environment Agency, 2009a)

Table 5.8 WFD Scenario B measures for Mayes Brook water body. Adapted from Thames River Basin Management Plan, Annex C: Actions to Deliver Objectives (2009a)

RBMP Table Field	Water Body relevant data
Pressure	Physical Modification
What will happen	Instigate channel restoration projects to improve flow regime and habitat creation
Where it will happen	Mayes Brook
Catchment	Roding, Beam and Ingrebourne (Mayes Brook)
When it will happen	2012
Means of Delivery	River Restoration Strategy
Lead Organisation	Environment Agency, Water Companies, other abstractors, Local Authorities, Developers, Thames River Restoration Trust
Driver for Action	WFD

The final dRBMPs consist of 15 separate sections (Main Document plus 14 Annexes) that comprise the assessment and plan of action for the river basin district to be implemented at the regional and local levels. The preparation of the draft Plans was in itself an iterative process which involved many internal working groups within the EA liaising with the Head Office WFD team, plus the regional River Basin District Managers and external Liaison Panels and advisory groups e.g. UK TAG.

5.3.4 Draft RBMP Consultation

During the six month consultation period (Dec 2008 – June 2009) public domain access to a small selection of responses to the dRBMP consultation from organisations in different RBDs was available via the WFD information centre (www.euwfd.com). These response documents revealed several common themes alongside other more sector-specific concerns. A review of these documents confirms that the main points of concern are effectively reflected in the Environment Agency Consultation Response documents for each district. However, delivery of the final Plans to the Secretary of State for approval was made less than two calendar months after the close of consultation. Given the complexity of the document, it is therefore unlikely that the consultation recommendations were fully incorporated within the first round of Plans. Some of the key themes expressed in the published responses (including the Association of Rivers Trusts (ART), Blueprint for Water, the National Farmers Union (NFU), Water UK) and picked up by the EA in their Response to Consultation documents (for each RBD) are summarised below.

5.3.4.1 Navigating, and understanding the dRBMPs

> *'Feedback we have received from Non-Governmental Organisations (NGOs) and partners across the country unanimously indicates that it is almost impossible to understand and respond to the [RBMP] consultation documents.'*
>
> (Blueprint for Water, 2009)

A common theme evident in several of the response documents (published online by the WFD Information Centre) was the difficulty for non-water sector groups and individuals to engage with the complex range of information (Blueprint for Water, 2009; Association of Rivers Trusts, 2009, National Farmers' Union, 2009). For some locations, information presented at the strategic (River Basin District) level, included only a limited amount of information about individual water bodies. Respondents noted this as an omission as the knowledge base of most participating stakeholders relates to individual water bodies at the sub-catchment or reach scale. CC Water (representing water consumers) suggested that providing more accessible information to conservation groups and wildlife trusts, who are important co-deliverers of the Plans, would also enable non-water sector stakeholders to contribute to achieving the WFD aims. Echoing the comments above regarding the scale of detail and participation in the Plan, the London Councils report calls upon the EA to work with Local Authorities to evaluate how actions would relate to individual water bodies and sectors.

The EA consultation response document reports that in all RBDs many respondents wished to *'comment in detail on proposals for individual water bodies'* i.e. to engage with information at the local scale (Environment Agency 2009a). The EA response emphasises the intention of the Plan to be a strategic high level document and where there may be several hundreds of water bodies in a single district, this level of detail is deemed to be unfeasible. However, in contradiction to this, they also state that the Plan will be amended to contain further clarified and geo-referenced (NGR) local scale information in Annex B (Objectives for waters). A further EA action will be to develop their existing interactive web-based tool WIYBY ('What's in Your Back Yard') to contain RBP information at the local scale for public access. ART also noted the value of the introduction of the proposed WFD local scale (WIYBY) tool to facilitate participation by co-deliverers. However the use of electronic maps was seen by others as potentially excluding, especially for rural stakeholders without access to broadband internet services (National Farmers' Union, 2009). Promotion of the WIYBY web tool however is welcomed to different degrees across the range of response documents.

5.3.4.2 Quality of information re: water body status, objectives, pressures and actions.

The inaccuracy of water body status and pressures was noted by NFU and Blueprint for Water, including the omission of hydromorphological pressures (Association of Rivers Trusts, 2009). Inconsistencies in the assessment and classification of heavily modified (HMWBs) and artificial water bodies (AWBs) between RBDs were noted by Water UK. The water industry also reported that the Plan was missing measures already happening (e.g. Water sector AMP actions) and that there was in general a lack of integration with other plans e.g. objectives and measures for already designated Protected Areas including Natura 2000 and Drinking Water Protected Area. These were duly acknowledged by the EA response with a confirmation of inclusion within the final Plans.

A lack of information regarding the assessment and determination of final status was raised in some districts (e.g. Anglian RBD, Severn RBD). Respondents requested more detail on the specific reasons for failure, especially when related to fisheries. A similar deficit regarding the use of derogations was also raised by Blueprint for Water and the ART. Greater transparency was called for together with concern for their level of use within the plan which was regarded as a lack of ambition and not in line with either the 'spirit' or the 'letter' of the WFD (Blueprint for Water, 2009)

5.3.4.3 Resourcing of actions

Water UK raised concerns expressed by the water industry that the apportionment of costs associated with WFD actions were not 'even handed' and fell disproportionately upon the water sector. This is closely linked to concerns regarding a lack of funding sources for other sectors to deliver WFD obligations and an over reliance on 'end of pipe' treatments rather than tackling problems at source as specified in WFD itself (EC, 2000, para 11). The London Councils (LC) also felt that although the objectives of the plan were understandable, there were issues associated with the costs involved in delivery and a lack of understanding of decision making processes and resource implications within local authorities. An overall concern for fairer apportionment of cost across more sectors was expressed through the EA response across several districts (Severn RBD, Northumbria RBD, North West RBD), as well as a general uncertainty about where funding would be found (Thames RBD, Anglian RBD).

5.3.5 Critique of WFD and RBMPs

Overall, the responses to the dRBMP consultation indicate that the WFD has been widely welcomed by the key stakeholders and well received as a forward looking, holistic methodology for sustainable management of the water environment and resources. Positive perceptions of the WFD include the capacity of the framework to be adaptive and not overly prescriptive (e.g. in comparison with the EC Habitats Directive 1992 which has strict requirements for specific species and habitats). Reservations to the Plans relate mainly to the opportunities to 'dumb down' or lessen the requirements to achieve Good Ecological Status or Potential and the perceived limited ambition of water body objectives and associated Programmes of Measures. The WFD principle of '*one out all out'* has also raised criticism amongst scientists due to potential misrepresentations of overall water body status if only one variable is poor (Borja and Heinrich, 2005).

5.3.5.1 Derogations and exemptions

Many fundamental criticisms of the WFD centre around the provision of derogations and exemptions which present opportunities to avoid penalties for not achieving good ecological status (GES) or potential (GEP) either due to (i) disproportionate cost, (ii) technical unfeasibility or (iii) where the over-riding human need for channel modification is greater (EC, 2000, Article 4.7). Howarth (2009) explains that from a legal point of view there is actually no obligation on Member States to achieve GES or GEP. The actual substantive requirement is that actions are undertaken to work towards non-deterioration and improvement of ecological status/potential. The potential use of Article 4(7) to justify a failure to meet WFD objectives is regarded by many as a means to lowering ambition of the Directive. This view is substantiated by the overt encouragement of the use of 'Alternative Objectives' by Defra within their River Basin Planning Guidelines, (Defra, 2006). Responses to the dRBMP consultation emphasise concerns that the emerging process of delivery is not '*in the spirit'* of the WFD (Blueprint for Water, 2009). For Ker Rault and Jeffrey (2008) these tensions are the result of a split between WFD aims and aspirations, and the implementation of the substantive content of the Directive through an integrated approach incorporating public participation. But Howarth (2009) goes on to describe how the WFD adopts an essentially process-orientated approach which will be refined via progressive reviews, and consultation through the iterative stages of the Directive.

5.3.5.2 Scale, expectation and subsidiarity

The unwieldy amount of content in dRBMP documents and the perceived ‘top down’ broad-scale approach makes the plans cumbersome for many and difficult to understand, despite the use of ‘plain English’ and non-technical explanations. The reactions of respondents from widely differing sectors to the inaccessibility of the information provided by the Plans, suggests that unfeasibly high expectations have been placed upon the RBMPs to perform and deliver at both high level and local scale. The implication that ‘think global act local’ and subsidiarity philosophies will translate into policy and meet both national/strategic plus local/personal levels through a single mechanism i.e. the RBMP, may therefore be a flawed assumption.

Proposed measures described within the RBMPs include a high proportion of non-statutory or voluntary measures, which often represent potential actions that carry the least certainty. Therefore, positive discourses with prospective co-deliverers, be it NGOs, local residents or business stakeholders, are of particular importance, especially when such parties may require motivation and direction to act effectively. The consultation response provided by the London Councils highlighted the difficulty for Local Authorities to understand (i) their role in delivering the actions to achieve WFD and (ii) how they might prioritise actions when a conflict arose within a planning context (London Councils, 2009).

While the Plan works hard to provide different levels of information at national (pressures), regional (types) and local scale (classifications) and plans for action (in line with WFD directions), it does not yet fulfil the need for information at the local level to facilitate delivery, nor does it explain how this will be met in future Plans.

5.3.5.3 Integrated water management

The dRBMP consultation responses cited above suggest that the opportunity to produce a new model of integrated water management via WFD appears initially, to have delivered a relatively inaccessible output. Ker Rault and Jeffrey (2008) explain that the new approach taken by WFD to achieve integrated water management in conjunction with public participation is inherently fraught with challenges as neither concept has consensual meaning or methodology in terms of objectives or priorities. This may be explained by the fact that they are both essentially complex and ‘wicked’ processes:

without rules and therefore open to ambiguous interpretations (Rittel and Webber, 1973). Ker Rault and Jeffrey (2008) suggest the reasons that no blueprint exists for public participation in integrated water management in WFD may be because:

(i) the process must be fitted to the national, regional and local circumstances of European Member States, acknowledging a differential ‘geography of governance’ under the WFD;

(ii) public participation needs to be adaptive and develop through delivery and iterative evaluation of what is most effective for each River Basin District;

(iii) WFD presents a non-prescriptive set of principles and expects Member States to take responsibility for their own laws and regulations for implementing the objectives;

(iv) due to the complexity of interdependencies and types of involvement of stakeholders there are fundamental differences in the interpretation of integrated water management and the role of WFD.

The emerging discourses emphasise the immaturity of the WFD participation and consultation processes. To be successful, the participation processes for a fully integrated WFD will need time to mature and benefit from an adaptive iterative approach as each successive Plan is updated and new practices emerge. Where different adaptations result in divergent models of participation, a flexible model of governance accommodating geographic differences may eventually emerge. In other words, by fitting information to the needs of the user, different patterns of engagement may develop and become spatially and socially distributed.

Overall, making the transition towards an assessment of aquatic resources and habitat based on living organisms is clearly welcomed by the scientific community as a demonstration of the current paradigm that advocates a systems perspective via the ecosystems approach (Hering et al. 2010). However, the reality of putting such a visionary framework into practice is proving to be a complex exercise that, for some respondents, threatens to fall short of WFD aspirations. As such, this represents an ‘implementation gap’ which future policy will need to address in practical terms.

5.4 Other environmental policy relevant to urban river restoration and management

Integrating ecological objectives for rivers into urban environmental projects (e.g. through river restoration into an urban park regeneration) introduces practical challenges for planning teams in terms of the scope of specialist knowledge and actions required to meet policy guidelines, especially for non-statutory measures. To achieve integrated outcomes for urban aquatic environments, project managers need to align river focused objectives with other environmental and urban planning policy, and to understand and communicate the value of combined environmental and social objectives to a diverse range of stakeholders.

The whole range of policy mechanisms that is involved in the delivery of the WFD is provided within a single annexe of each RBMP (Annex F: Mechanisms for action). For the Thames RBMP (2009) the content of this annexe alone constitutes 61 pages, including references to over 40 separate Directives, Acts, Regulations and Orders etc relating to water quality and quantity, wildlife conservation, building regulations, town and country planning, land drainage, waste disposal and more. While recognising the interconnectedness of different sectors and interests related to the integrated management of aquatic environments it also highlights their potential for fragmentation and the complexity for practitioners wishing to engage in such projects.

The policy documents included in this analysis represent high and intermediate level policies with relevance to urban river restoration projects, indicated by the Mayes Brook case study scoping report (Table 5.1). A selection of the main policies relevant to physical rehabilitation of urban rivers is provided in Table 5.9 and the opportunities and challenges associated with the main policy areas are discussed below.

5.4.1 Habitat and biodiversity policy

For many Local Authorities, the Biodiversity Action Plans (BAPs) present a clear focus to guide Parks or Conservation Officers managing natural environments within their boroughs. The main challenge for urban river restoration projects is that there is only a low association between the priority BAP species or habitats e.g. water vole or reed beds, and the WFD indicators of good ecological habitat (fish, invertebrates and macrophytes). However, the WFD indicators are less well known to borough environmental officers so BAP targets remain a focal point, thus missing important opportunities to improve river ecosystem condition and function through local-scale measures (Hammond, RRC, 2011 Pers. Comm). The advisory role of the River Restoration Centre (RRC) includes extensive support to non-river professionals involved in river projects on appropriate (a)biotic indicators for monitoring the outcomes of improvement works. The RRC Practical River Appraisal Guidance for Monitoring Options (PRAGMO) produced in partnership with the EA, and currently under trial, has been developed as a guide to support a wide range of practitioners in post-project river habitat and biodiversity appraisal and management (RRC, 2011).

The EC Habitats Directive is of less direct relevance to urban catchments as this focuses specifically upon protected habitats such as Sites of Special Scientific Interest which are more commonly found in rural areas. However, under the 1949 National Parks and Access to the Countryside Act, areas that represent locally important sites for wildlife, geology, access to greenspace and environmental education may be declared and managed by local authorities as Local Nature Reserves (LNR). Likewise, areas of Metropolitan Open Land are also of strategic importance to regional and local planning. As such, both designations contribute to Natural England's Access to Natural Greenspace Standard (ANGSt), which recommends access to at least 2 hectares of natural greenspace within 300m (or 5 minutes) walk from home, and a minimum of one hectare of LNR per 1000 population (Natural England, 2010).

5.4.2 Flood risk management policy

> *'Solving the problem of future intra-urban flooding by engineering alone would be prohibitively expensive. Instead an integrated approach will be vital.'*
>
> (Foresight Future Flooding Report, OST, 2004)

An important policy landmark for urban rivers was the introduction of Defra's 2005 'Making Space for Water' policy, which advocates integrated solutions to flood risk management through the use of natural flood storage and Sustainable Urban Drainage Schemes (SUDS): methods which both reduce the rapid urban run-off rates and allow more water to be retained within the soil, vegetation, other porous substrates or retaining features such as swales. The role of river restoration in linking the WFD approach to integrated river basin management with flood risk management (FRM) is highlighted by Wharton and Gilvear (2006). Their paper reports on the high degree of synergy between policies emerging after a series of devastating flood events across the UK in Easter 1998 and Autumn 2000, which in the latter case affected over 1000 properties in 700 locations causing and estimated £1.0 billion of damage (Wharton and Gilvear, 2006). Following investigations, UK government and independent reports all emphasised the benefits of integrated, catchment scale management approaches and the use of flood storage and naturalisation techniques to attenuate flows within river catchments where feasible (Defra, 2005; OST, 2004). The abundant evidence also emphasises the integrated benefits of flood storage and biodiversity through the creation of wetland or washland habitat which, through periodic inundation, has the potential for diverse habitat creation and support (Ward et al. 1999; Downs and Gregory, 2004).

Despite extensive support and endorsement for river restoration techniques as FRM and biodiversity enhancement strategies, there is limited evidence to demonstrate these synergistic approaches in practice. While the use of SUDS is emphasised in planning guidance PPS25 (DCLG, 2006) and some notable examples exist, e.g. Milton Keynes, wider uptake by the engineering industry has been slow (Newman, Quartet Design, 2010, Interview comment). The need for '*a learning culture that values integration and participatory decision making*' is highlighted by Brown (2005, p.466) whose research identifies technocratic institutionalised inertia as a major constraint to implementing integrated and sustainable stormwater management solutions in Australia. Although there is scope within UK strategic planning approaches to establish integrated drainage controls, research by Digman et al. (2006) also found that at the local level, a strong leading partner and effective communication with stakeholders were the most influential aspects to ensure successful planning and delivery of SUDS.

Positive outcomes for urban river restoration include recognition of the need to review historic engineering approaches and the provision of resources specifically for the rehabilitation of channels impacted by hard flood defences (England, EA, 2010 Interview comments). For example, major flooding in the Ravensbourne-Quaggy catchment in 1968 in Lewisham town centre focused the attention of the Local Authority and the EA upon the need for improved FRM. The removal of toe boards and creation of flood storage opportunities within several river stretches demonstrates opportunistic implementation of such rehabilitation works, delivered via a catchment-scale management perspective (LB Lewisham, 2010).

Table 5.9 Summary of environmental policy influencing urban river restoration

Policy	**Description**
EU Habitats Directive (92/43/EEC)	The Habitats Directive gives prescriptive direction for habitat conservation; specifies areas of importance to rare or threatened species or habitat to be designated as Special Areas of Conservation, which contribute to the Natura 2000 network (along with Special Protected Areas designated under the Birds Directive, 1979). **Key actors include: Natural England, London Wildlife Trust**
Biodiversity – the UK Action Plan (HMSO, 1994)	The UK Biodiversity Action Plan (UK BAP) represents the UK governmental action under the Convention on Biological Diversity (1992). The UK plan provides a list of priority habitats and species for the UK; structure includes National scale Biodiversity Groups, Local Biodiversity Partnerships plus Local and Regional Strategy Implementation Groups. At the regional scale, the Local BAPS are the delivery mechanism produced and managed by Wildlife Trusts and/or the Local Authority in partnership with the Environment Agency and local conservation bodies. The significance for urban river management involves the conservation of important aquatic and riparian species e.g. water vole and habitat e.g. chalk streams **Key actors include: Environment Agency, Natural England, London Wildlife Trust**
The Countryside and Rights of Way (CRoW) Act, (England & Wales only) (HMSO, 2000)	The Countryside and Rights of Way (CRoW) Act, 2000 outlines the duties of governmental bodies regarding conservation of biodiversity in accordance with the Convention on Biological Diversity. Under the CRoW Act, areas protected as SSSIs due to special biological features must be managed to support the relevant species or habitat. In urban catchments, Local Nature Reserves contain locally important habitats or species and are owned and designated by the local authority, where these contain a SSSI, management is specific to the protected features. **Key actors include: Regional and Local Government departments.**
Making Space for Water, (Defra, 2005)	Following consultation on river and coastal flood management in the UK in 2004, 'Making Space for Water' aims to take an integrated approach to managing risks from river and coastal flooding and coastal erosion in order to: i. reduce the threat to people and their property; ii. deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles; and iii. secure efficient and reliable funding mechanisms that deliver the levels of investment required to achieve the strategy. iv. to link with habitat creation objectives within river corridors through managed realignment and setting back new lines of defence (Defra, 2005).

	This strategy significantly supports the aims of urban river restoration in terms of removing hard defences where room for floodwater storage exists for example where rivers pass through urban parks and open spaces. (Judy England/EA, personal comment, 2009). **Key actors include: Environment Agency, Local Authorities**
England Biodiversity Strategy - Climate Change Adaptation Principles, (Defra, 2008)	To support the guidelines for conservation of UK BAP species and habitats, this document recognises the main threats to biodiversity associated with climate change as changes in phenology (i.e. species synchrony), species abundance, community composition, ecosystem processes and loss of space. The principles outlined are: - Take practical action immediately - Maintain and increase ecological resilience - Accommodate change - Integrate action across all sectors - Develop knowledge and plan strategically (Defra, 2008) **Key actors include: Environment Agency**
Planning Policy Statement (PPS)25: Development and flood risk, updated March (Department of Communities and Local Government, 2010)	PPS25: Development and flood risk requires Local Planning Authorities to take flood risk into account for all new development; to direct new development away from areas of high risk; to use the 'Sequential Test' to evaluate the suitability of proposed development location with reference to the borough wide Strategic Flood Risk Assessment (SFRA) – a spatial planning tool which defines areas with urban development opportunities in relation to EA defined flood risk zones. The general principles in Annex E support the development of sustainable urban drainage and natural flood storage at new development sites. Although river restoration is not specifically mentioned, the guidance provides much support for the application of integrated water body planning and refers frequently to the River Basin Management Plans for the appropriate guidance on local water body management for developers and planners. **Key actors include: Local Authorities; Environment Agency; Developers**
London Rivers Action Plan, (EA, 2009)	The LRAP represents the joint ambitions of the GLA, EA, Natural England and voluntary organisations such as River Restoration Centre, and the River and Wildlife Trusts to deliver the restoration of 15 km of Thames tributaries by 2015. One of the main case studies championed in the LRAP is the case study site at Mayesbrook Park. Key actors include: Environment Agency, Local Authorities, RRC, River Trusts, Wildlife Trusts.

Current requirements for Scottish Local Authorities to take a greater management role in FRM, introduced by the Flood Risk Management (Scotland) Act 2009, is already placing demands on these bodies to acquire greater knowledge of river science and integrated catchment scale approaches (Richardson, 2011; The Scottish Government, 2011). Similar proposals for England will also present challenges to many boroughs especially where river catchments extend across multiple administrative units. Recognition of this by the GLA within the London area was highlighted through the London Mayor's 'Help a London Park' (HeLP) project for LA project managers engaging in a river restoration as part of their scheme, and the suggestion of trans-borough catchment focused river specialists raised as an option for future strategic river management (Massini, GLA, 2010, Interview comment).

5.4.3 Climate Change Adaptation policy

The UK Climate Impacts Programme (UKCIP) provides Defra with the Climate Projections through which the precautionary principle may be applied to policy concerning approaches for sustainable management of both biodiversity and flood risk. The probability based climate change projections produced in 2002 (known as UKCIP02) are used within flood risk planning guidance: PPS25 to provide actual factors for potential increases in precipitation (+5% to 2025) and river flow (+10% to 2025) to be used for flood risk assessment in planning applications (DCLG, 2010). The most recent climate projections (UKCP09) are used in the development of Defra's Adapting to Climate Change Programme and available to registered users in the public domain, with tools for local authorities, advisors and businesses to investigate impacts (www.ukcip.org.uk/, Box 5.4).

At the regional level, climate change policy for London, produced by the London Climate Change Partnership (consisting of Natural England, London Biodiversity Partnership, Greater London Authority and London Development Agency), also highlights the needs for increased urban greening, flood storage and habitat resilience to support biodiversity. The role of urban rivers in supporting these aims is demonstrated by case studies such as Sutcliffe Park, Greenwich, which emphasise how objectives can be achieved through integrated river restoration projects. Guidance and recommendations to the Mayor, specialist advisors and local level delivery partners include the establishment of a regional level Rivers Restoration Group who aim to identify opportunities and priorities, develop further guidance, promote demonstration projects and to engage communities and raise awareness of the need for these actions (LCCP, 2009).

Box 5.4 Summary of UK Climate Impacts Programme web based tools, methods and guidance used to support Defra's Adapting to Climate Change Programme (Source: www.ukcip.org.uk/tools)

Adaptation Wizard takes you through a process to determine your vulnerability to climate change, identify your key climate risks, and develop a climate change adaptation strategy. It is also a guide to all of UKCIP's information, tools and resources.

AdOpt is guidance that explores the nature of adaptation in the context of climate risk.

BACLIAT (Business Areas Climate Impacts Assessment Tool) helps users explore the implications of climate change for their business or sector.

CLARA (Climate Adaptation Resource for Advisors) is aimed at helping business advisors to support small and medium enterprises (SMEs) in understanding and preparing for the impacts of climate change.

Costing the impacts of climate change is a methodology for calculating the costs of climate impacts and how to compare these to the costs of adaptation measures.

LCLIP (Local Climate Impacts Profile) is a resource that local authorities can compile so that they better understand their exposure to weather and climate.

Risk framework is a step-by-step decision-making framework to help you judge the significance of your climate change risk compared to the other risks you face, so you can work out what adaptation measures are most appropriate.

SES (Socio-economic scenarios) help explore what future worlds might look like and to consider how our vulnerability to climate change and adaptation responses might vary with different future worlds.

UKCP09 offers background and key findings for the latest future climate change information, UK Climate Projections. Headline messages from the previous climate change scenarios are also available.

5.5 Planning policy and urban environmental regeneration

Urban planning legislation also has a major influence on the restoration of urban rivers and streams and the integrated management of their ecosystem services. Urban regeneration includes economic (investment), environmental (spatial) and associated social improvements which have been delivered since the late 1990s through a combination of Regional Development Agencies (established under RDA Act, 1998) and (independent) Urban Regeneration Companies (established in 1999). The most recent non-departmental government initiative, the Homes and Communities Agency, initially lead by English Partnerships (since 1998), was taken over by the Department of Communities and Local Government (DCLG) in 2008, coinciding with the Housing and Regeneration Act.

The Single Regeneration Budget (SRB), dating from 1984, was a funding tool used by the government to support regeneration initiatives and reduce the gap between deprived and other areas. The SRB was subsumed into the RDA Single Programme (Single Pot) resource plan from 2002 (www.communities.gov.uk/). Local Strategic Partnerships (associated since 2000 with Neighbourhood Renewal – National Strategy Action Plans) drive Local Area Agreements (LAAs) and were a condition for deprived local authorities that received funding via the Neighbourhood Renewal Fund (NRF) initiative. It is evident that the main focus of urban regeneration since the 1990s has been upon redressing social inequalities both through job creation and environmental improvement.

5.5.1 UK Planning system and policy

The main features of the English planning system date back to the Town and Country Planning Act of 1947. Reforms contained within the Planning and Compulsory Purchase Act (2004) emphasise environmental protection and sustainability and introduced the duty '*to contribute to the achievement of sustainable development'*, however Bell and McGillivray (2006, p.460) describe the extent to which this is mandatory as '*debatable'*. The main components of the planning process include: (i) borough level Strategic and Local Development Plans (Table 5.10); (ii) a Development Control process: whereby a Local Planning Authority (LPA) can grant planning permissions, and (iii) the power to impose conditions and agreements such as those under Section 106 (s.106, Town and Country Planning Act, 1990) relating to the requirements for 'environmental gain' to balance the impacts of development (Bell and McGillivray, 2006). As such, s.106 provides an important source of revenue for local environmental rehabilitation projects as is demonstrated by the evidence presented in section 6.3.

Table 5.10 Two tier system and London (not including the (lower tier) Waste and Minerals development plans) adapted from Bell and McGillivray, (2006).

Strategy or plan		**Plan making body**
	LONDON *	
UPPER TIER		
Regional Spatial Strategy	Spatial Development Strategy	Regional planning body
LOWER TIER		
Local Development Plan Documents: (i) Local (general) (ii) Minerals (iii) Waste	Local Development Plan Documents (include Minerals and Waste)*	(i) Local planning authority (District Council or UDA) (ii) County council or UDA (iii) County council or UDA
Documents not forming part of ‘the development plan’: (i) Supplementary planning docs (ii) Statement of community involvement		(i) District or County Council or UDA (ii) District Council or UDA
* (all London Boroughs are unitary authorities)		

National planning guidance is currently delivered through Planning Policy Guidance (PPG) or Statements (PPS), with associated implementation guidelines provided by the Department of Communities and Local Government (DCLG). A scoping report investigating the links between the WFD, development control and planning policy, highlights the importance for ‘plan makers’ to engage with emerging water policy (DCLG, 2006). WFD legislation applies to all water bodies including those near to or within regeneration areas, and therefore has direct relevance to urban planning. The primary WFD objectives of preventing a deterioration of ecological status (via chemical, hydrological and morphological impacts) have implications for development which may carry risks of sediment or pollutant transfer, on both short and longer time scales. As mentioned in section 5.2.6 , a major area of concern for river managers lies in the interpretation of Article 4(7) which may negate the need to prevent deterioration or achieve good ecological potential or status or where such failures are ‘*the result of new modifications to the physical characteristics of a surface water body..*’ (EC, 2000 p.11).

While planning decisions are guided by the PPG/PPS literature, the planning process overall is based on negotiation and consultation between planning authorities and developer. Although public consultation also plays an important role for individual applications, the consultation process may be undermined in favour of making rapid decisions (Bell and McGillivray, 2006). Alongside the National Planning guidelines, further extensive policy exists at the regional and local levels to guide and integrate local developments with environmental objectives e.g. LB Barking and Dagenham Landscape Framework Plan (LBBD, 2008) and Parks and Green Spaces Strategy (LBBD 2004a). The borough strategic plans set out the broad scale vision for the distribution of different types of development and provide a starting point for individual applications. For example, under PPS25, individual applications are first required to determine suitability for the location of a proposed development location through the 'Sequential Test' in relation to the Strategic Flood Risk Assessment and Local Authority Development Plans, which identify optimal areas for development in relation to areas of flood risk. PPS25 imposes conditions for proposed developments in areas of high flood risk rivers i.e. > 0.1% or 1 in 1000 years probability, or on sites greater than 1ha and outlines the primary responsibility of the developer to carry out a flood risk assessment (DCLG, 2006). The potential of Sustainable Urban Drainage Systems (SUDS) and green roof technology to greatly reduce catchment runoff rates and thus the potential local flood peak, is also emphasised throughout PPS25 and supporting guidance, however SUDS application is not a mandatory requirement.

A summary of some of the main policy that is relevant to development at the national and regional level (specific to London) is provided in Table 5.11. A more detailed breakdown of the planning guidance relevant to key aspects of the Mayes Brook restoration project is also shown in Table 5.12 to demonstrate the complexity associated with integrated planning scenarios for urban river restoration project managers.

While awareness of the need to protect valuable green spaces from development has focused attention on brownfield regeneration and development, there has been less attention upon the regeneration of urban green or blue spaces, their ecological functions and services, and benefits to the local wildlife and human communities cohabiting the river floodplain. Such sites may coincide with derelict urban brownfield or larger public amenity areas. The implication is that as a 'non-market driven' activity with less opportunities for investment returns there has been less motivation towards regenerating public open spaces or urban riparian spaces with aquatic biodiversity or flood storage potential. This is surprising, considering the extensive use of water in corporate development and recognition of the aesthetic value of aquatic environments in for

Table 5.11 Summary of planning related policy influencing restoration of open spaces

Planning policy	**Description**
National	
Planning Policy Guidance / Planning Policy Statements	Broad ranging planning policy guidelines used to inform Development Control by Local Authorities and Environment in planning application assessments
Section 106 Agreements (Town and Country Planning Act 1990)	Produced as part of a planning permission, a Section 106 agreement is a legally binding planning obligation between the LA and landowner which can be used to deliver or address issues that are necessary to make a development 'acceptable in planning terms' this may include the provision of 'services and infrastructure .g. highways, recreational facilities, education, health and affordable housing' as well as environmental benefits. (www.idea./gov.uk)
Local development framework (LDF)/ Unitary Development Plans (UDPs)	In response to changes to the planning system introduced by the government in 2004, local authorities are currently in the process of developing new for Local Development Frameworks to replace their UDPs (introduced in 2006). The new LDFs will emphasise increased involvement of local community and stakeholders and consist of Local Planning Documents (LPDs) LDF adoption should be completed by 2011.
Regional (London)	
The London Plan - Spatial Development Strategy (SDS)	Strategic planning guidance for London was replaced by the London Mayor's spatial development strategy in 2004.
Thames Gateway development plans	Strategic planning tool targeting areas to the east of the Thames catchment
East London Green Grid Framework – Supplementary Planning Guidance (SPG)	To complement the expected increases in development in E. London and impacts of climate change, the Green Grid strategy aims to ensure that priority will be given to ensure a network of 'interlinked, multi-functional and high quality open spaces'

example Docklands areas. Historic perceptions of urban blue spaces as polluted drainage and flood conveyance infrastructure and a disregard of the value of the multiple ecosystem services that blue corridors provide in urban environments appears to prevail in many cases. Pinch and Munt, (2002) suggest that reasons for this disregard and the lack of recognition of the multi-functional potential of water spaces are due to and confusion within the regulatory framework that is based on terrestrial criteria about responsibilities and objectives.

Table 5.12 Planning policy (England and Wales) cited as relevant to urban river restoration case study Mayes Brook (adapted from Table 5.1)

Code	Planning policy statement - Full name	Waste & Minerals: Contaminated land: Air: Noise	Water Resources	Ecology and Nature Conservations	Recreation and Tourism	Landscape and visual amenity	Land use; built environment; socio-economics; traffic & transport	Cultural Heritage & Archaeology
PPS 1 & Supplement	Delivering Sustainable Development; Planning and Climate Change					✓	✓	
PPG 2	Green Belts			✓		✓	✓	
PPS 3	Housing						✓	
PPS 5	Planning for the Historic Environment							✓
PPS 6	Planning for Town Centres						✓	
PPS 7	Sustainable Development in Rural Areas			✓	✓	✓	✓	✓
PPS 9	Biodiversity and Geological conservation			✓				
PPS 10	Planning for Sustainable waste management	✓						
PPG 13	Transport						✓	
PPG 14	Development on Unstable land	✓						✓
PPS 17	Planning for Open Space Sport and Recreation			✓	✓	✓	✓	
PPS 23	Planning and pollution control	✓						
PPS 24	Planning and noise	✓						
PPS 25	Development and Flood Risk	✓	✓	✓				
PPG15; PPG16 – Cancelled and replaced by PPS 5, March 2010								

Criticisms identified through research by Bell and McGilllivray (2006) identify further areas of concern for environmental practitioners, concerning planning processes that appear to result in a trade off between environmental and non-environmental assets (Box 5.5). Overall, planning processes are permissive and planning authorities can weight material considerations differently with each development reviewed on an individual case basis. The use of planning contributions to provide environmental benefits (i.e. under s.106 of Town and Country Planning Act, 1990) is mainly used as a compensatory mechanism. However in an urban context, this has delivered significant resourcing opportunities for river restoration as demonstrated by the evidence presented in Chapter 6. Since the 1990s planning narratives and discourses have become dominated by environment and sustainable development, however, the extent to which these have influenced practice is still in question and the subject of ongoing research (Potter, 2008). Although the focus on sustainable development has become embedded in national policy, as final decisions, made at the local level are discretionary and based on individual merit (Bell and McGillivray, 2006 p. 460), it appears that the delivery of sustainable development operates more on a strategic than a local level.

Box 5.5 Summary of UK Planning System critique (Adapted from Bell and McGillivray (2006 p. 462)

- patchy incorporation of environmental considerations
- lack of mention in PPG/S of nature conservation
- priority attached to economic interests
- planning authority view environment as a commodity or service and ecological references are rhetorical
- lack of integration with other key sectors e.g. transport
- focus on business interest and desire to create jobs

5.5.2 Regional and local development plans

The integrated role of river and water bodies in urban environments is also acknowledged within the current Green Infrastructure discourses promoted by the regional authority for London, the GLA and Natural England. The recognition and integration of the ‘Blue Ribbon’ network and ‘Blue Spaces’ with urban greenspaces and green infrastructure in relation to development and access, is demonstrated by several policy documents including the recently updated London Plan (GLA, 2011, p.241). Here this is demonstrated by associations made between maps and policy references to the river network in association with the green infrastructure (p.70) where Policy 2.18 (Green Infrastructure: The Network of Open and Green Spaces) states that:

> *‘Development proposals should: encourage the linkage of green infrastructure, including the Blue Ribbon Network to the wider public realm to improve accessibility for all and develop new links.’* (GLA, 2011, p.70)

However, located within a different chapter (7), the adjacent sections on ‘London’s Open and Natural Environment’ and the ‘Blue Ribbon Network’ indicate a much lower degree of integration between the green/terrestrial and blue/aquatic natural environments. In the former section, the only mention of aquatic environments appears within a table summarizing London’s BAP habitat targets which include Coastal and Floodplain grazing marsh; Tidal Thames; Rivers and streams; Standing water; and Fen, marsh and swamp habitats (ibid, p.237). The latter ‘Blue Ribbon Network’ section includes seven separate policies (listed in Box 5.6) covering a range of water related activities including tourism, transport, recreation and restoration for rivers, canals and the tidal Thames, however, no mention of flood or floodplain management was found within this section, as it is considered separately under Climate Change Adaptation (ibid, p.153). These examples indicate different levels of integration and associations between issues which are driven by current areas of concern. For example, linking flooding with climate change reflects a risk management approach and popular concern in the former issue rather than the creation of natural flood storage and associated BAP habitats to reflect a ‘working with nature’ biodiversity led ecosystems approach.

5.5.3 Local scale: Mayes Brook case study

As part of the Landscape Framework Plan for the London Borough of Barking and Dagenham, ‘Policy Cr2: *Preserving and Enhancing the Natural Environment’*, sets out borough priorities for the biodiversity and habitats found within the local area. This includes many named wetland and landscape features, which are valued and recognised as contributing to the borough community priority of ‘*Making Barking and Dagenham cleaner, greener and safer’* (LBBD, 2008). Other strategic greenspace plans specific to the borough include the Parks and Green spaces Strategy (LBBD, 2004a) plus

Box 5.6 List of policies in The London Plan linked with 'Blue Ribbon Network'

Policy number and name	
7.24	Blue Ribbon Network
7.25	Increasing the use of the Blue Ribbon Network for Passengers and Tourism
7.26	Increasing the use of the Blue Ribbon Network for Freight Transport
7.27	Blue Ribbon Network: Supporting infrastructure and recreational use
7.28	Restoration of the Blue Ribbon Network
7.29	The River Thames
7.30	London's Canals and other rivers and waterspaces

additional documents specific to Mayesbrook Park, including the Local Nature Reserve management plan, (LBBD, 2004b); Lakes Management Plan (LBBD, 2001b).

The evidence from the Mayes Brook scoping report indicates the breadth of policy documents identified as relevant to this case study (Table 5.1). In terms of meeting the requirements of the WFD, the restoration works provide an opportunity to integrate improvements to ecological potential in an otherwise heavily modified river system with increased public awareness of natural flood storage approaches. Raising the profile of the need for water quality improvements within the catchment will also support the ongoing work of Thames Water to address the misconnections affecting the brook; the delivery of a public engagement programme through the creation of a new 3-year park ranger post will support WFD subsidiarity; as well as ongoing plans to deliver a monitoring strategy for the river and park to record the ecological and social benefits and improvements associated with the restoration works.

5.6 Conclusions: Integrating policy initiatives

The review of current legislation and policy provided in this section reveals varying levels of environmental and social integration within individual 'joined-up' policies operating at regional (e.g. London Plan, GLA, 2011) to European level (WFD). However, the variety of approaches to integration and complexity in coordinating different policy objectives also provides challenges for practitioners aiming to deliver integrated projects at the local level. Furthermore, whilst the lead delivery organisations are focusing on delivering their own integrated approaches, they also need to coordinate with each other. For example, key initiatives relating to the restoration of London rivers and floodplains operating in parallel and managed separately include the LRAP (EA et al. 2009) and Natural England's 'Integrated Projects' e.g. in the Lee and Wandle valleys (http://www.naturalengland.org.uk/regions/london/ourwork/integratedprojects.aspx).

The review of WFD discourses reveals the challenges for the EA as competent authority in delivering the varied measures proposed to meet the ecological objectives. Subsidiarity principles, fundamental to WFD delivery, have determined that stakeholder engagement must be effective in order to achieve integrated water management. Put simply, a joint effort by all sectors of society is needed to deliver and sustain environmental improvements. Within urban catchments, the multiple impacts upon rivers are highly damaging, however human resource is also abundant. The non-prescriptive approach taken by the WFD criticised by some (5.2.6) also provides considerable scope for River Basin managers to refine new approaches through the RBMP 6-year review rounds. In this way the 'implementation gaps' identified may be addressed and the RBMPs used as 'live' working documents to be adapted in response to observed outcomes.

At the regional level, the London Plan also integrates environmental and social elements through the Blue Ribbon Network and Green Grid initiatives, which also provide the opportunity for trans-borough catchment scale coordination (5.1.2). Current delivery of conservation efforts by different borough authorities perpetuates catchment fragmentation across administrative boundaries, however the expansion of the East London Green Grid to cover 'All London' will support other river corridor focused initiatives and liaison between neighbouring boroughs (GLA, 2009).

Despite the current abundance of supportive policy, obstacles to taking action to improve urban rivers at the local level also arise through uncertainties of ownership and management responsibilities, which are typically split between the Environment Agency, the Local Authority or other private riparian owners. This confusion over governance responsibilities alongside the general lack of awareness of the importance and value of urban rivers and the ecosystem services they provide highlights the value of identifying ways to engage and communicate effectively with non-river experts about urban river options and to enable stakeholder involvement in their long term rehabilitation.

In the light of the policy frameworks reviewed here, Chapter 6 examines the evidence from the RRC and LRAP databases to discover to what extent multiple objectives have been driving river restorations in London since the 1980s; and the character of partnership and funding structures involved in their delivery.

Chapter 6: Results III – Policy into practice

6.1 Introduction

The aim of this chapter is to ground the policy context described in Chapter 5 through evidence of practice, by looking for evidence for interdisciplinary approaches and integration of environmental and social objectives through current and historic data resources. This chapter examines some of the tools available for urban river restoration planning and sustainable management and considers how these can lead towards more ecologically robust and socially coordinated outcomes. In preparation for the case study investigation of partnership and environmental governance practice in Chapter 7, this chapter begins by investigating the information resources available to practitioners to support urban river restoration.

The chapter first provides a brief review in Section 6.2, of the increasing number of environmental information systems accessible to practitioners and researchers and their practical role in relation to urban river management: as repositories of environmental evidence and effective tools for recording and investigating the state of the environment (6.2.1). Also, to what extent these multiple knowledge stores are mutually exclusive or integrated and thus able to support interdisciplinary approaches.

The chapter then explores a historic perspective of London river restoration through secondary data gathered by the River Restoration Centre (RRC) and London Rivers Action Plan (LRAP) managers. The purpose of section 6.3 is to shed light upon the practice of urban river restoration in London since the 1980s. The historic London restoration project data are first reviewed (6.3.1) and then interrogated to provide insights into objectives (6.3.2), partnership structures (6.3.3) and funding (6.3.4) for completed, ongoing and proposed river restoration projects in London. A final review of these data resources for London restoration practitioners and evidence for changes in practice since the 1980s is provided in section 6.3.5. This period includes the earliest stages of implementation for the LRAP and RBMP policy tools and suggests potential indications of the development of urban river restoration practice for future stages.

The final section (6.4) presents background evidence for the case study restoration projects and provides insights into the planning and management histories of each case study site. This section closes with a review of the site history and planning context for the main case study at Mayes Brook as a prequel to chapter 7 which explores the project management and delivery of the restoration in detail.

This section concludes with an historic view of London river restoration in relation to the time line of the case study projects. It compares observed changes in practice with the historic data findings and considers the sequence of practice characteristics over time, what has been learned from historic practices and the indications for future urban river restoration planning and design.

6.2 Urban River Planning: Environmental information systems

6.2.1 Environmental data resources for urban river restoration

The management of environmental data resources in the UK is evolving in line with technological developments as new online data resources (or e-data) continue to enter the public domain. This phenomenon reflects a global trend in geo-database development e.g. by the United Nations Environment Programme and World Resources Institute, and extensive environmental data coverage in the US. A sample of e-resources available to London urban river practitioners is shown in Table 6.1.

The new e-data sites share a common objective of disseminating environmental knowledge in the public domain. Created by a range of organisations for a variety of purposes, (e.g. ‘State of Environment reporting’, educational, social, etc.) with coverage focused at either national or regional scales. The majority of e-data resources include interactive maps; many are fully accessible without constraint and include links to specialist information stores. Sites with restricted content require user registration or subscription for access to sensitive information (e.g. Greenspace information for Greater London, GiGL protected species data) or information covered by intellectual property rights. Several sites also include data gathering functions which permit surveyors to upload data for simple analyses (e.g. the Natural History Museum site OPAL); or to share knowledge of favourite places (e.g. Thames 21 Waterways Treasure map); or for surveyors to contribute to wildlife sightings or data survey records (e.g. GiGL).

Table 6.1 A selection of online environmental information systems for London. (Accessed August 2011)

Name of Database (Organisation)	**e-Database description**	**Type of data**	**Query(Q) / Upload (U) function**
Biodiversity Action Reporting System (BARS) (Defra) Launched 2003	http://ukbars.defra.gov.uk/	National; Record of BAP plans and individual actions for BAP habitats and species	Q / U
DigiMap (British Geological Society with EDINA) (Launched 1996)	http://www.bgs.ac.uk/products/digitalmaps/digmapgb.html	National; Geological (Bedrock and superficial) data: free access to 1:625000; higher resolutions for purchase; iGeology app	Q
Greenspace information for Greater London (GiGL) Launched 2006	http://www.gigl.org.uk/	Regional/London; Ecological datsets (habitat/species); Free access to interactive maps; WIMBY / WildLink searches; Data upload function for surveyors;; Charged reporting for consultancies.	Q / U
London Air quality network (Kings' College London)	http://www.londonair.org.uk/london/asp/default.asp	Regional/London; Free access to interactive map of air quality; Live feed contains updates of latest air quality news	Q
London Environment summary (Office for National Statistics)	http://www.statistics.gov.uk/cci/nugget.asp?id=2322	Regional/London; Summary of environmental and socio-economic factors; Free access	Q
London Rivers Action Plan (EA / RRC) Launched 2008	http://www.therrc.co.uk/lrap.php	Regional/London; Restoration case studies map linked to pdf case study summaries; data upload for practitioners	Q / U
MAGIC (Defra & Natural England) Launched 2002	http://magic.defra.gov.uk/	National; Ecological data resource, interactive map;	Q
Nature on the Map (Natural England)	http://www.natureonthemap.naturalengland.org.uk/	National; Nature reserves; SSSIs; BAP habitats; Geological sites etc	Q
OPAL (Natural History Museum / UCL)	http://www.opalexplorenature.org/OPALWater	National; Educational resource; Ecological, Water Quality database for Lakes and ponds; data upload for surveyors	Q / U
River Restoration Centre (RRC)	http://www.therrc.co.uk/rrc_case_studies.php	National; Interactive map; links to case study summaries	Q

State of the Environment Report for London June 2011 (GLA)	http://data.london.gov.uk/datastore/package/state-environment-report-london-june-2011	Regional/London; PDF Report, June 2011; Data also available to download as excel spreadsheet	Q
Urban River Survey (QMUL)	http://www.urbanriversurvey.org/holding	Regional/London; In development: Biophysical river habitat data; Interactive map and assessment tool	n/a
UK Rivers Network	http://www.ukrivers.net/index.html	National; Community and Educational resource; Map of local river groups; Links to data and further resources	Q
Waterways Treasure Map (Thames 21)	http://www.thames21.org.uk/treasure/default.php	Regional/London trial; coverage limited to trial boroughs; Interactive map of 'favourite places' for: Angling; Anecdotes; Wildlife spotting etc	Q / U
What’s in your Backyard (EA)	http://maps.environment-agency.gov.uk/wiyby/	National; Flood risk maps; River levels; Pollution; Water Quality; RBMPs; Groundwater etc	Q
WildWeb (GLA)	www.london.gov.uk/wildweb/	Regional/London; Wildlife Map; Search engine	n/a

6.2.2 Environmental data access and integration

The integration of online data resources provides a focus for environmental research by the Natural Environment Research Council (NERC), demonstrated by the recent launch of their £2m programme the ‘Virtual Observatory’ a ‘proof of concept’ project which aims to develop a resource that will coordinate and increase the accessibility of environmental data, to be available for the ‘whole community’ [sic] to support monitoring and decision making (www.environmentalvirtualobservatory.org/). This represents a highly significant development as extensive data availability, common in the US, is not mirrored in the UK as many data holding agencies (e.g. the EA) will charge to provide information. Withholding data is often used either as a mechanism to protect private companies in relation to industrial practices or licensing compliance or a means of raising revenue from private consultancies and as such limits research opportunities by academics or local practitioners.

An important role for e-data systems in river management and urban river restoration is to share information between practitioners and non-river experts, including information about other projects – what was done; what the outcomes were; who was involved; and how much projects cost, etc. However, issues over data ownership and control over interpretation present areas of potential concern.

Online searches for environmental data during 2010-11 suggest that a great deal of web-based information relates to biodiversity records. For example, within London, the Greenspace information for Greater London (GiGL) database represents a regional partner of the National Biodiversity Network, and 43 other environmental partner organisations within London. The GiGL database provides a centralized databank for information on habitats, species and open spaces across London. Much information is freely available through the interactive spatial (‘What’s In My Back Yard’) or themed map searches (e.g. by species or habitat).

As a data provider GiGL aims to ‘*make available all records no matter how sensitive, with the appropriate interpretation*’ but will restrict data where this may pose a risk to endangered species or compromise the supply of data (Grafton, 2009). Data held by GiGL include records uploaded by a wide range of organisations and individuals who enter an agreement via a ‘Data use licence’, which permits data exchange and covers issues around intellectual property rights and data ownership. The validation and verification of data records is controlled by the GiGL Recorder Advisory Group and GiGL policy which states that ‘*All records are considered correct by GiGL, and may be used in reporting, until such time as assessed by expert.*’ at which time, the record will be issued with a verification category (Blank/Null; Correct; Considered incorrect; Unverifiable) determined by the affiliation of the recorder and expert opinion (GiGL, 2011).

It is inevitable that online data resources will reflect the culture and primary interests of host organisations as well as reflecting areas of policy demand (which are likely to underpin the funding of such resources). However, as the GiGL example demonstrates, the general requirements for data validation and management for all types of data can be highly labour intensive and require a robust and transparent protocol. An investigation in the following section of data available online through the RRC and LRAP databases (provided to RRC members on request in MS Excel format) explores the content of these web based data resources for urban river restoration further.

6.3 Historic practice: Analysis of RRC and LRAP data

This section explores London river restoration practice from a historic perspective using data from the River Restoration Centre (RRC) and London Rivers Action Plan (LRAP) databases recorded between 1983 and 2011. Using data provided by urban river project managers for London projects only, the main objectives for restoration are reviewed. This is followed by additional analyses of the partnership structures, cost of restoration and a breakdown of funding by sector for London river projects where data are available. Although the total costs for recorded projects may also include non-river components e.g. landscaping greenspaces within the riparian or floodplain areas, each project consists primarily of an urban river restoration and therefore all the data recorded represent the scales of budget and characteristics of partnership relating to the integrated project of which the river works represent a focus.

The aim of this section is to analyse data extracted from the RRC and LRAP databases to provide background information for London river restorations in relation to

i. Type and number of objectives for urban river restoration projects;

ii. Partnership structures for urban river restoration projects;

iii. Funding sources for urban river restoration projects;

iv. Average annual expenditure for London river restorations

6.3.1 Data preparation and quality check

Before analysis, the content and coverage of the two databases were reviewed with respect to (i) coverage of the London area, (ii) timing of projects, and (iii) information relevant to the present investigation (i.e. objectives, partnerships and funding). Table 6.2 summarises the data held in the RRC and LRAP data bases for the London area. The RRC database covers the whole of the UK dating back to the 1970s. The RRC data provided were first filtered by ‘County’ to extract records for ‘London’ only. This generated 285 data entries for London (including the Northeast and Southeast Thames EA areas) with the earliest dated entry recorded as 1983. Of these, 128 had a ‘Year start’ or ‘Year end’ date within the period 2008 to 2010.

The LRAP database only contains records from the London area. It was set up in 2008 and holds 195 entries relating to restoration projects recorded between 2008 and 2011; however it is noted that some undated entries may represent pre-2008 restorations. The

LRAP database not only holds more entries than the RRC database for the 2008-11 period but also more detailed information regarding aspirations, motivations and funding. Therefore, in some analyses only information from the LRAP dataset was analysed.

Table 6.2 Summary of the data content for RRC (London only: 1983-2011 and 2008-2011 periods) and LRAP data bases

	RRC: London/Full No. records (%)	**RRC: London/Dated (08-11) No. records (%)**	**LRAP No. records (%)**
Data filter(s):	Spatial: County: London	Spatial /Temporal: County: London; Year Start OR End: 2008-2011	none
Total number:	285	145	195
Dated records:	1983-2011	2008-2011	2008-2011
Total number dated:	208 (73.0%)	145(100%)	16 (7.7%)
OBJECTIVES			
- motivations	272 (95.4%)	123 (84.8%)	109 (55.9%)
- aspirations selected	n/a	n/a	186 (95.4%)
PARTNERSHIP			
main contact	260 (91.2%)	121 (83.4%)	194 (99.5%)
- funding organisation	112 (39.3%)	73 (50.3%)	83 (42.6%)
- non funding partners	57 (20.0%)	45 (31.0%)	54 (27.7%)
- other funders	22 (7.7%)	11 (7.6%)	n/a
COST			
- cost total (values >0)	89 (31.2%)	48 (37.2%)	47 (24.1%)
YEAR			
- year started	189 (66.3%)	127 (87.6%)	n/a
- year ended	67 (23.5%)	23 (15.9%)	16 (7.7%)

The information in both databases was patchy, as is revealed in Table 6.2 by the widely varying percentages of data entries relating to the areas under investigation: i.e. objectives, partnership, cost and year. For example, the full LRAP data set carried a low proportion of data for objectives recorded as ‘motivations’ (55.9%) compared to the 2008-11 London RRC data (84.8%) but a higher proportion of objectives recorded as ‘aspirations’ (95.4% entries). Comparison of the relative proportions of data content for each data set is facilitated by the bar chart shown in Figure 6.1.

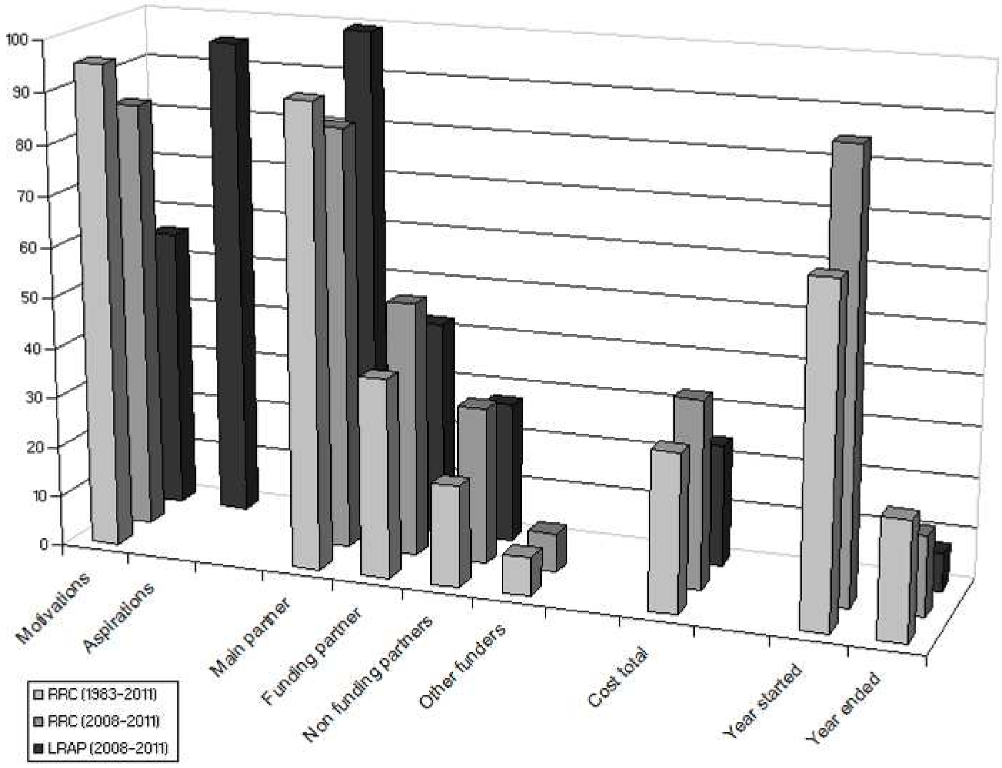


Figure 6.1 Comparison of the percentages of total data entries within the LRAP and RRC datasets (for two time periods) in the areas of investigation: objectives (as motivations/aspirations); partnership; cost and year.

A review of the year start/end data entries revealed major gaps in both data bases, significantly limiting the potential to perform temporal analyses. In order to identify potential duplication within the RRC and LRAP datasets for 2008 onwards, the RRC data were sorted by Year Start and Year End to identify all projects initiated or completed for 2008 onwards. The 2008-11 London RRC data set could then also be compared to the full London RRC data set (dating back to 1983). The 2008-11 RRC data set was found to contain an atypical number of data entries with 2008 as the starting year, possibly reflecting an influx of data coinciding with the launch of the LRAP. In contrast, the LRAP does not include a field for ‘year start’, and the ‘year ended’ field is very poorly populated (7.7%), carrying far fewer entries and a lower proportion than the equivalent time period in the 2008-11 RRC sub-set (15.9%). Due to these uncertainties, the RRC ‘year end’ data were used to investigate changes in average annual project costs through time, with supplementary information provided for comparison by the dated LRAP entries for 2008-11.

Although the very low frequency of dated records prevented a more robust analysis of temporal changes in restoration governance for London rivers, comparative analysis of the full RRC (1983-2011), dated RRC (2008-2011) and LRAP (2008-2011) data sets enabled an investigation of emerging trends in London river restoration practice since the 1980s.

6.3.2 Objectives

Differences in data recording between the RRC and LRAP data bases led to an investigation of objectives recorded as ‘motivations’ (RRC/LRAP) and ‘aspirations’ (LRAP only).

6.3.2.1 Objectives recorded as ‘Motivations’

The data fields headed ‘Motivations’ were interpreted as an indicator of project objectives for London river restorations. Entries for ‘Motivation’ relate to a restricted number of selectable options that are common to each database (indicated by the x-axis labels in Figure 6.2). Entries specified as ‘Others’ in the LRAP database were compared to the combined entries for the additional ‘Opportunistic’, ‘Bank erosion’ and ‘Pollution prevention’ categories provided in the RRC database. A frequency distribution of recorded motivations reveals the sequential importance of restoration drivers for the three different data sets. Arranging these data together shows the degree to which the LRAP (black bars) and 2008-11 RRC (dark grey bars) data reflect those of the longer term (post-1983) RRC London data (light grey bars). These data illustrate that habitat improvement has consistently been the strongest motivation for restoration within London for the both time periods. However the LRAP data also suggest an increase in community demand and fisheries motivations in recent years. It is possible that the additional data captured by the LRAP database reflects the increased involvement of local authorities, which would also account for a recorded increase in community demand.

A comparison of the percentage frequencies of projects with different numbers of motivations (Figure 6.3), suggests a slight increase in the average number of motivations for 2008-2011 projects. The LRAP data is more evenly distributed around the mean (2.8) and mode (3) of motivations per project compared to the post-1983 data (mean 2.58; mode 3). The greater proportion of projects with 3 or 4 motivations recorded by the LRAP database appears to reflect the inclusion of more social objectives (Figure 6.2).

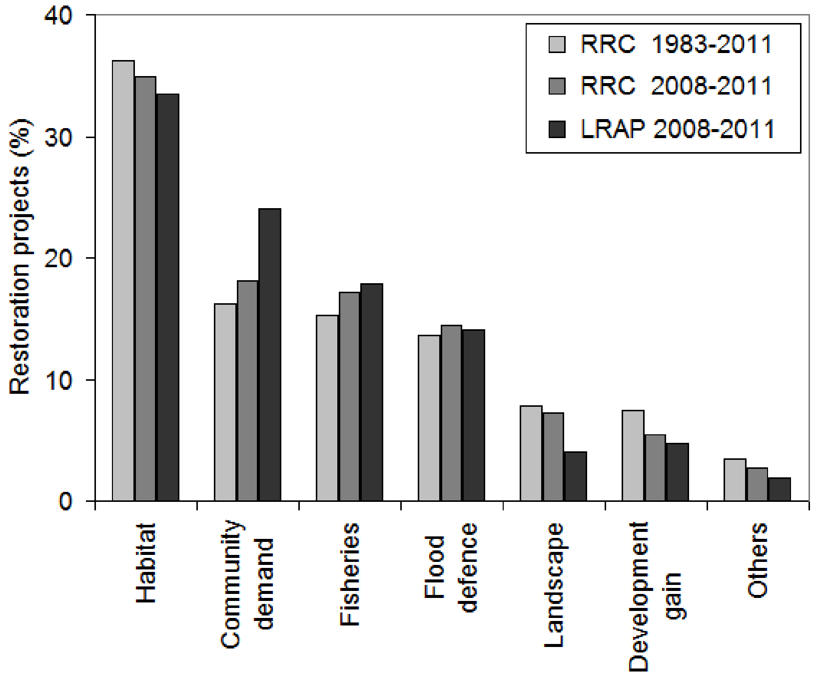


Figure 6.2 Motivations for London river restoration: Comparing post-1983 and 2008-2011 data recorded by the RRC and LRAP databases.

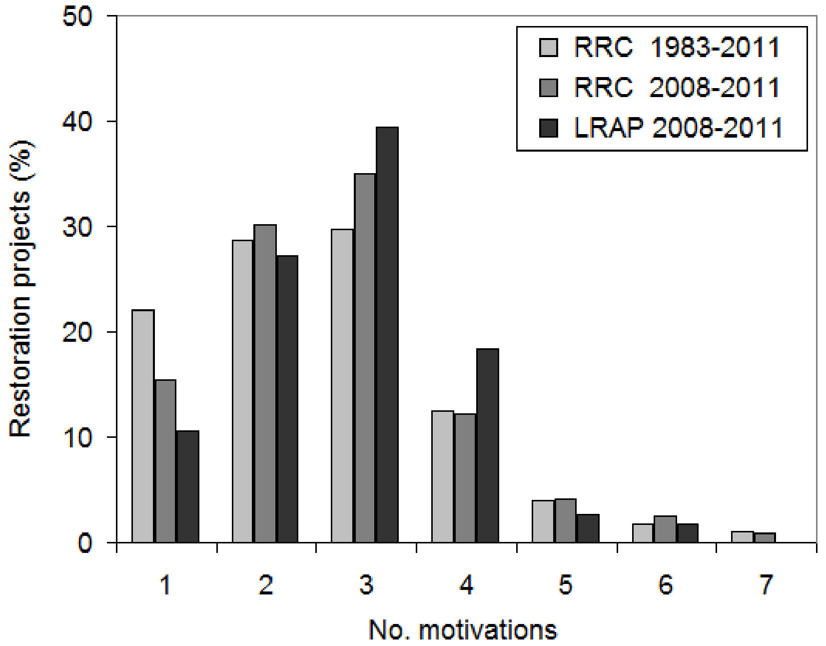


Figure 6.3 Comparison of the number of motivations per project for post-1983 and 2008-2011data recorded by the RRC and LRAP databases.

Similar analysis of the national RRC database carried out in 2000 (Bruce-Burgess, 2004) indicated that in the Thames region, the main focus for restoration was ecology (35% , 64 projects) followed by fisheries (11%, 20 projects), Bank erosion and development gain each accounted for a further 7% (2 x 13 projects) with no mention of community demand (Bruce-Burgess, 2004, p.120), suggesting that the proportion of the latter appearing in Figure 6.2 may represent restorations recorded 2008-2011.

Bruce-Burgess (2004) reported that a high proportion of projects were funded from the EA flood defence revenue budget, which was confirmed by interview for this project (Scott, EA, 2010, Interview comments). However, this was not mentioned as being the main focus for restoration, in contrast to the evidence revealed by this project. Bruce-Burgess (2004) does not mention whether all the motivating factors analysed here were included in this previous research, but since multiple objectives were a focus of the present research, all motivating factors were included in the analysis with equal weighting.

6.3.2.2 Objectives recorded as ‘Aspirations’ (LRAP data only):

The opportunity for project managers to record their aspirations for urban river restoration was introduced in 2008 with the LRAP information system. The high frequency of responses (95.4%) and more detailed specification of aims provided by the database managers via ‘tick boxes’ for each category, prompted analysis of these data. The analysis shows that the aspirations for 31% of reported London river restorations include ‘Biodiversity Enhancement’, closely followed by ‘Access and Recreation’ (24.2%), projects indicating Climate change, Urban Regeneration or Flood Risk Management as aspirations ranged from 14.3 to 15.7% (Figure 6.4).

When the same data are sorted according to the project stage, the nature of the aspirations in relation to planning and delivery progress is revealed (Figure 6.5) A high number of projects are recorded as ‘Concept only’ compared to the relatively low number of ‘completed’ projects, reflecting the short period over which data have been collected for the LRAP database. However, the relative proportions for each aspiration vary little between the development stages, with slightly higher proportions for ‘Climate Change’ for early stage and completed projects, and slightly lower proportions for ‘Flood Risk Management’ for projects with commitment to delivery, funding and detailed design. These trends reflect the policy focus on future risks of climate change, but not those for flood risk management, despite the support for the development of natural flood storage opportunities through river restoration (section 5.4.2, Flood policy objectives).

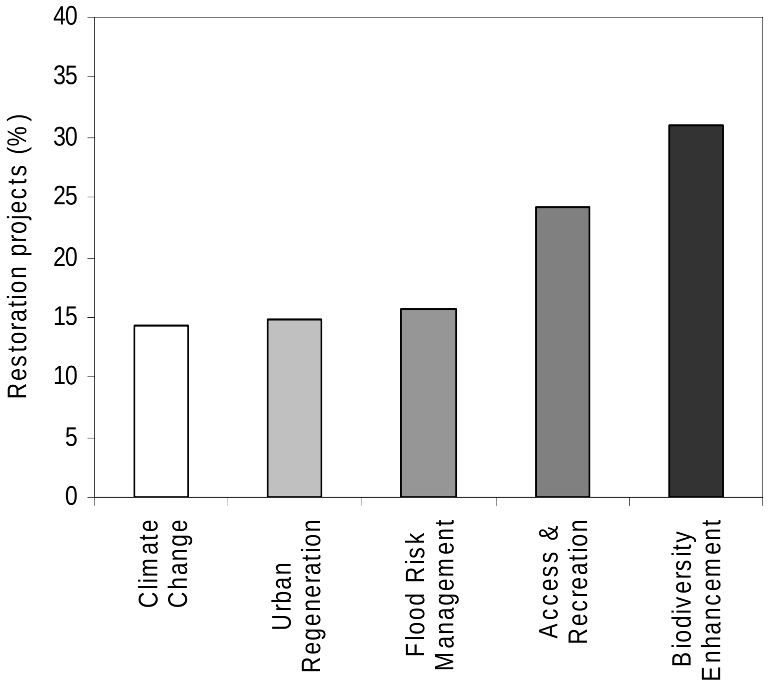


Figure 6.4 Percentage frequency of projects in London citing specific aspirations for river restorations. Source: LRAP data 2008-2011.

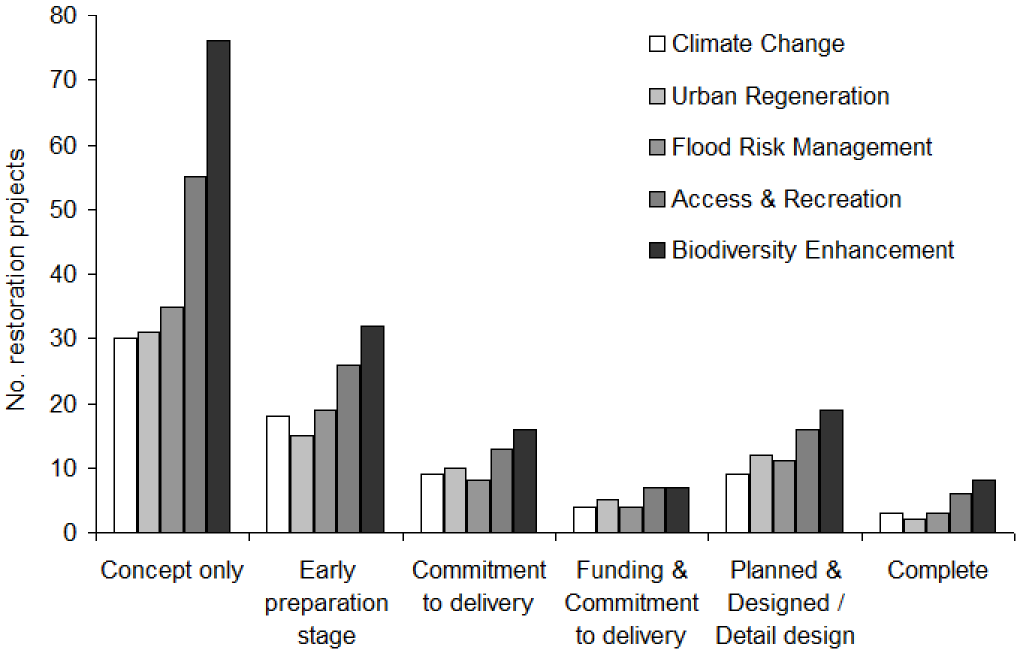


Figure 6.5 Numbers of projects in London citing specific aspirations for river restoration, sorted by project stage. Source: LRAP data 2008-2011.

6.3.3 Partnership structure

It proved difficult to extract meaningful information on partnership structures from the data bases. Both RRC and LRAP databases provided partner data under fields labelled ‘Main contact’, ‘Non-funding partners’ and ‘Main funders / Main funding organisation / Other funders’. Although some funders or funding organisations may not themselves be active partners (e.g. developers providing resources via s.106 planning agreements), it was not possible to differentiate between active and passive partners, therefore all were included within the analysis. Due to the greater number of data entries and high percentage response (99.5%), the LRAP data alone were used for the partnership structure analysis for restoration projects during the period 2008-2011.

The numbers of partners listed per project for each planning stage was investigated first. For each project planning stage, the total number of partners was calculated by summing entries in all relevant fields, and ranged from 0 to a maximum of 9 partners (Figure 6.6). For many projects, only one partner was listed (usually as the main contact). While this was the case for all project stages, there were a disproportionately high number of single partner projects at the ‘concept only’ stage, a stage when other partners may not yet be committed. By contrast, the relatively high numbers of partners (up to nine) involved in concept and early stage projects suggests widespread stakeholder interest in project proposals.

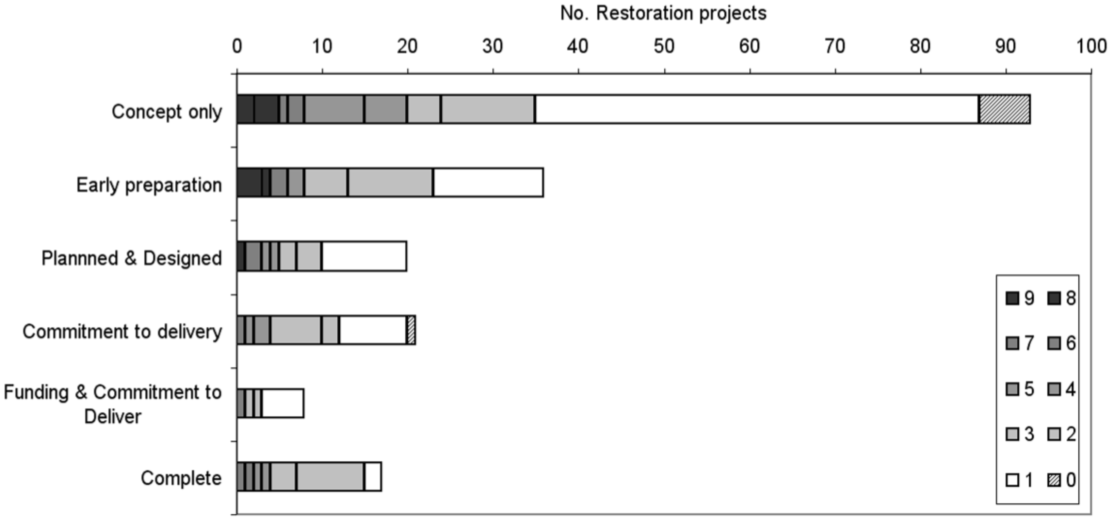


Figure 6.6 Numbers of partners involved in restoration projects, sorted by planning stage. Source: LRAP data only.

Further understanding of the distribution of partnership groupings across the project stages was extracted by counting the entries for each organisation within the three data fields representing the partner types (funding partners, non-funding partners, main contact) and by grouping each organisation by sector or sub-sector (Table 6.3). The percentage frequencies of projects with the involvement of the different identified organisation types in relation to their project roles are listed in Table 6.4 and illustrated in Figure 6.7.

QUANGO partners were associated with the highest numbers of projects for all partner categories, reflecting the prominence of the EA within this group, acting as either project lead or the main LRAP contacts in the majority of London river projects. A notably high level of involvement by Local Authorities as non-funding partners was indicated (55.6% of the projects with data recorded in this field). Also involvement by community and charity organisations were each recorded for 24.1% of all projects with partner data.

While the majority of funding partners were found to represent a QUANGO, this was closely followed by ‘developers’, ‘local development’ or recorded as s.106 resources, suggesting but not confirming that these may in some cases represent ‘silent’ partners or funding sources. Further high proportions of projects had funding partners belonging to private sector organisations or central government bodies, e.g. Defra (Table 6.4).

Table 6.3 Overview of organisations involved in urban river restoration 2008–11. Source: LRAP database.

Organisation Type or Sector	Organisation or funding source (as listed)	Funding role?
Planning	106 Agreements	✓
	Local development / Developers e.g. Seager	✓
QUANGO	EA; EA/FRM capital	✓
	BW - British Waterways (Public corporation)	✓
	Natural England	✓
	London Riverside BID (QUANGO?)	
	Design for London	✓
	Design for Biodiversity	
Private sector / Environmental levy	Thames Water (settlement / rehabilitation fund)	✓
	Carillion Natural Habitats Fund	✓
	Private company e.g. RSA, SUN	✓
	School /College / University	✓
	Private land owners	✓
	Landfill tax e.g. SITA; Veolia Environment Trust; Biffaward; Viridor;	✓
	Aggregates Levy Sustainability Fund	✓
Govt: Central	Community infrastructure levy	✓
	Green infrastructure / Green Grid	✓
	DEFRA grant (through EA)	✓
	Communities and Local Government (CLG) Parks Budget	✓
	Neighbourhood Renewal Fund (2001-6, NRF)	✓
	Single Regeneration Budget (SRB)	✓
Community	Local Volunteers Charity e.g. Wimbledon conservators; Wandle Piscators; Richmond Park Wildlife Group	✓
	Local community groups: Friends of Beddington Park; Friends of River Crane (FORCE); local school; Marsh Farm Auotmers; QWAG; Twickenham rifle club; Allotments	
	Angling club	
	Crane valley partnership	
Charity	World Wildlife Fund (WWF)	✓
	National Trust / Community Therapy Programme (CTP)	✓
	The Royal Parks	✓
	Wandle Trust	✓
	Groundworks	
	Wild Trout Trust	
	Thames 21	
	River Restoration Centre (RRC)	

	Zoological Society of London (ZSL)	
	London Wildlife Trust (LWT)	
	Grantscape / Small scale grant applications	✓
Govt: Local	Local Authority	✓
	Capital Budget - ASM /other	✓
Govt: Regional	Mayors Parks Programme/ Help a London Park (HeLP)	✓
	Greater London Authority (GLA)	✓
	Lee Valley Regional Park Authority (LVRPA)	✓
Lottery	Heritage Lottery Fund (HLF)	✓
	Access to Nature (A2N)	✓
	National Lottery	✓
Development agency	London Thames Gateway Development Corporation (LTGDC)	✓
	Olympics Development Agency (ODA)	
	Barking Riverside Ltd (Public Private Partnership, PPP)	✓
	London Development Agency (LDA)	✓
EU	EU Life+	✓
	European Regional Development Fund (ERDF)	✓

Table 6.4 Numbers and proportion of projects with partners from different types of source organisation Source: LRAP data only

	Funding partners	**Non-funding partners**	**Main contact** (if not already counted)
TOTAL no. projects	83	54	194
Sector or organisation type involved			
	% of projects	% of projects	% of projects
Development (s106)	43.4	14.8	0.0
QUANGO	59.0	74.1	41.2
Private sector / Environmental levy	34.9	14.8	7.7
Govt: Central	24.1	1.9	0.0
Community	6.0	24.1	2.6
Charity	8.4	24.1	7.7
Govt: Local authority	13.3	55.6	8.8
Govt: Regional	14.5	14.8	1.5
Lottery	9.6	0.0	0.0
Development agancy	7.2	3.7	2.1
EU	8.4	0.0	0.0
General / Other	1.2	0.0	0.0

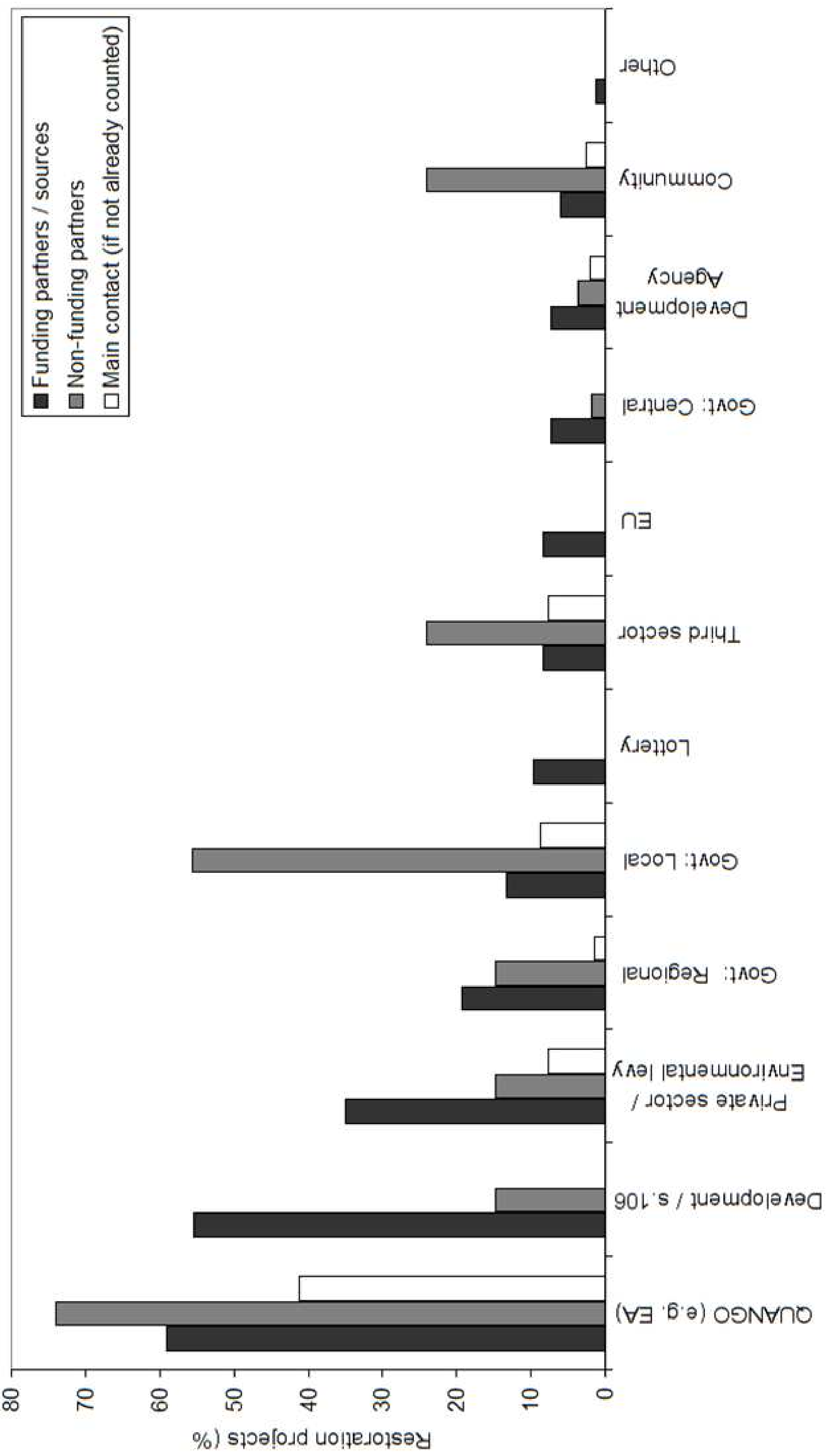


Figure 6.7 Bar chart illustrating distribution of partner roles undertaken by different types of source organization. Source: LRAP data only.

6.3.4 Cost and financing

Data recorded for funding partners and total costs within each database were explored to gain insights into sources of finance and integrated approaches to funding London river restorations in relation to overall levels of expenditure.

6.3.4.1 Funding sources

The range of different funding organisations (Table 6.3) indicates the diversity of sponsorship for the restoration of urban rivers and associated greenspaces. The high proportion of funding organisations represented within the overall list of partners reflects high levels of support for the regeneration of aquatic environmental resources within London. A review of the funding partners and proportions of projects being sponsored by each type of sponsor (Figure 6.7, Table 6.4) demonstrates that the four leading funding providers are QUANGOs (59%), Development gain/s.106 (43.4%), Private sector sponsors (including landfill taxes, 34.9%), and Central Government (24.1%). Smaller but significant numbers of projects are also being sponsored by Regional (14.5%) and local (13.3%) government. Lottery and charity funding accounted for 9.6 and 8.4% of projects respectively, with local community organisations contributing to a further 6% of projects, and the EU funding 8.4% of river restoration projects with funding partner data.

These figures indicate a diversity of sources of funding for urban river restoration, as well as the main areas of support. While there was a maximum of 9 partners for a few projects, up to 5 of whom were funding partners (Figure 6.8), for the majority of projects with data, only one or two funding sources were indicated, suggesting this is the most common funding model. However, the very high proportions of projects with no data recorded for funding partners, also suggests gaps in the data and therefore only a partial indication of funding structures.

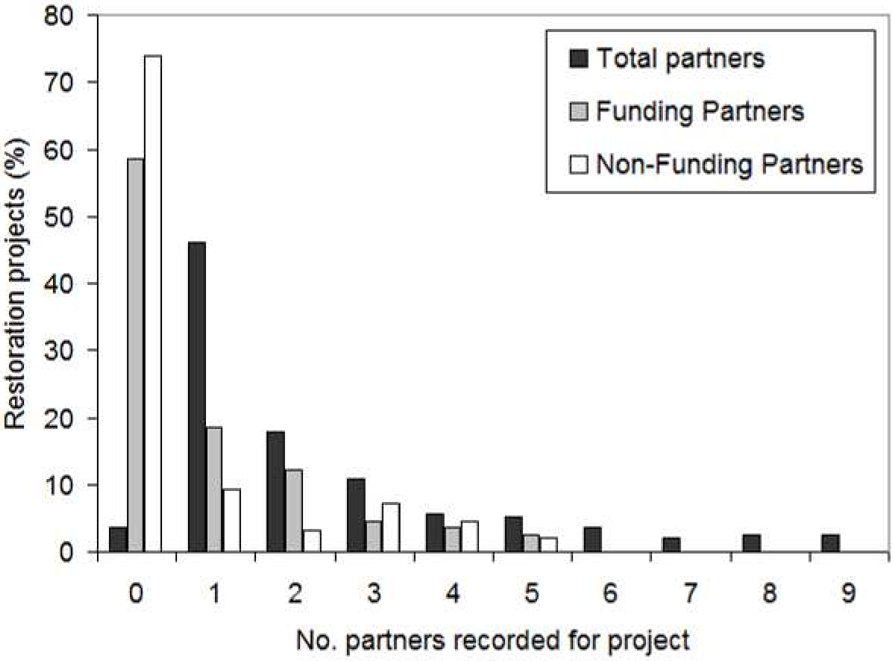


Figure 6.8 Proportion of projects with different numbers of partners and types. Source: LRAP data.

6.3.4.2 Expenditure on London river restoration

Analysis of projects with data entered under 'total cost' revealed a high proportion of entries for both RRC and LRAP data sets showing £0 in this field. The proportion of projects with total cost data was disappointingly low: 24.1% for the LRAP data; 37.2% for the RRC post-2008 data. The maximum total cost recorded for a London river restoration project was £6m (for the Moselle Brook restoration, Lordship Park, Tottenham, to fully deculvert the brook into a newly landscaped wetland and flood storage area, and includes the restoration of historic features within the park). A histogram of percentage frequencies of restoration projects within a logarithmic scale of cost ranges (Figure 6.9) reveals that project costs in the £10,000s bracket are the most common. It is important to note that the costs provided for river projects, in many cases represent the combined costs of river and park restoration, as demonstrated by the high total cost for the Moselle Brook project.

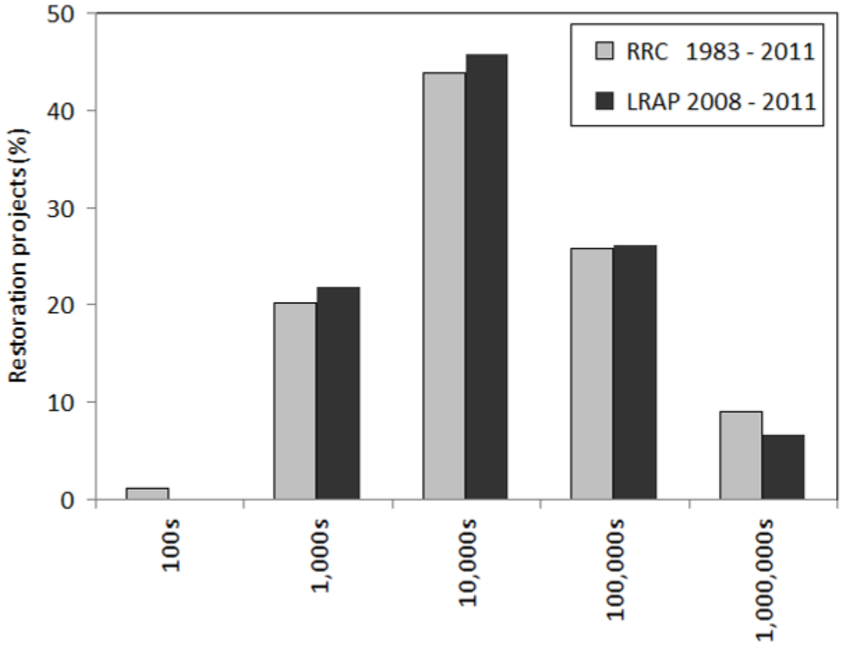


Figure 6.9 Percentages of restoration schemes with total cost data within different funding brackets.

In order to investigate changes in spending on London river restoration since the 1980s, the ‘Year end’ dated entries were sorted and illustrated as a bar chart showing the numbers of projects without (-) and with (+) cost data available for analysis (Figure 6.10). The available total cost data were then used to calculate an annual average total cost for each year and database. The ‘average annual cost’ data generated were then adjusted to take account for inflation using the Bank of England online Inflation Calculator (*www.bankofengland.co.uk/education/Pages/inflation/calculator/flash/default.aspx*) and illustrated, first as a bar chart using a logarithmic scale for pounds spent (Figure 6.11) as well as a scatter plot showing spend (£m) plotted against project year end (Figure 6.12).

The results suggest that average spending on river restoration in London has been consistently high, around the £100,000s mark since 2003. Although a drop in spending is indicated in both datasets for 2009, the LRAP dated entries indicate a return to this the previous spending level in 2010 and 2011. While the trend line shown in Figure 6.12 suggests there may be evidence of an increase in spending on river restoration in London since the 1980s, regression analysis indicates that this is not a significant relationship, with an R^2 value of less than 0.1%.

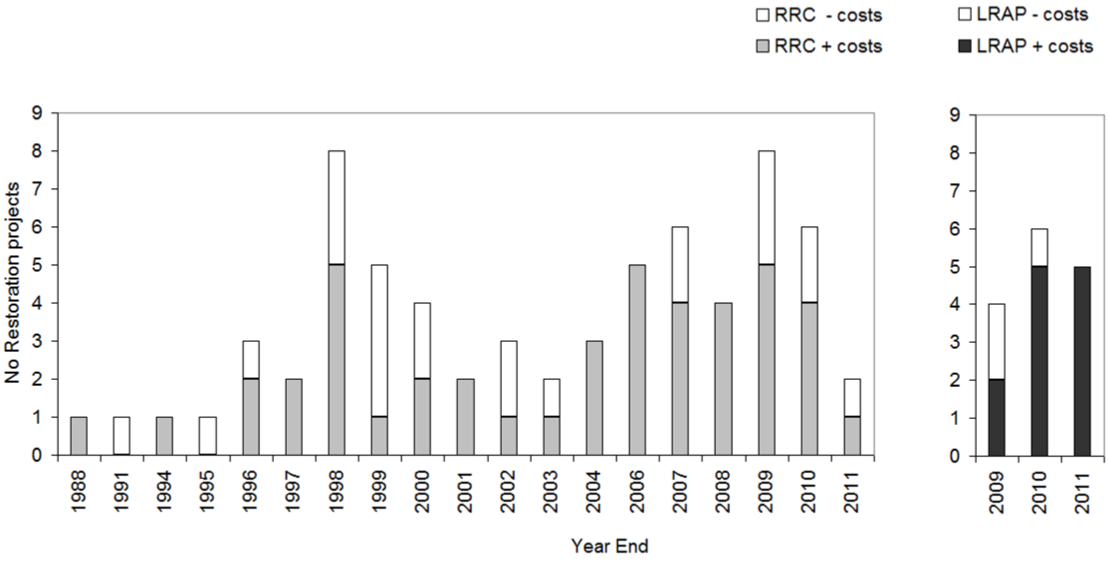


Figure 6.10 Distribution of data with(+) or without(-) cost data for RRC and LRAP databases.

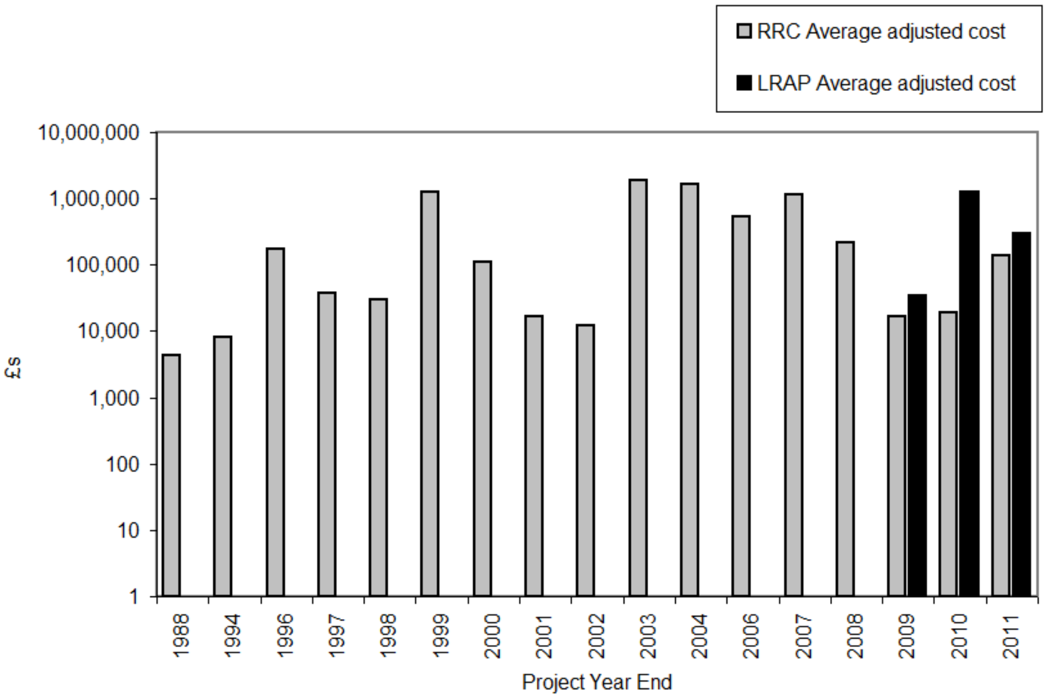


Figure 6.11 Average cost data (adjusted for inflation) recorded for London river restoration projects between 1988 and 2011 on RRC and LRAP databases.

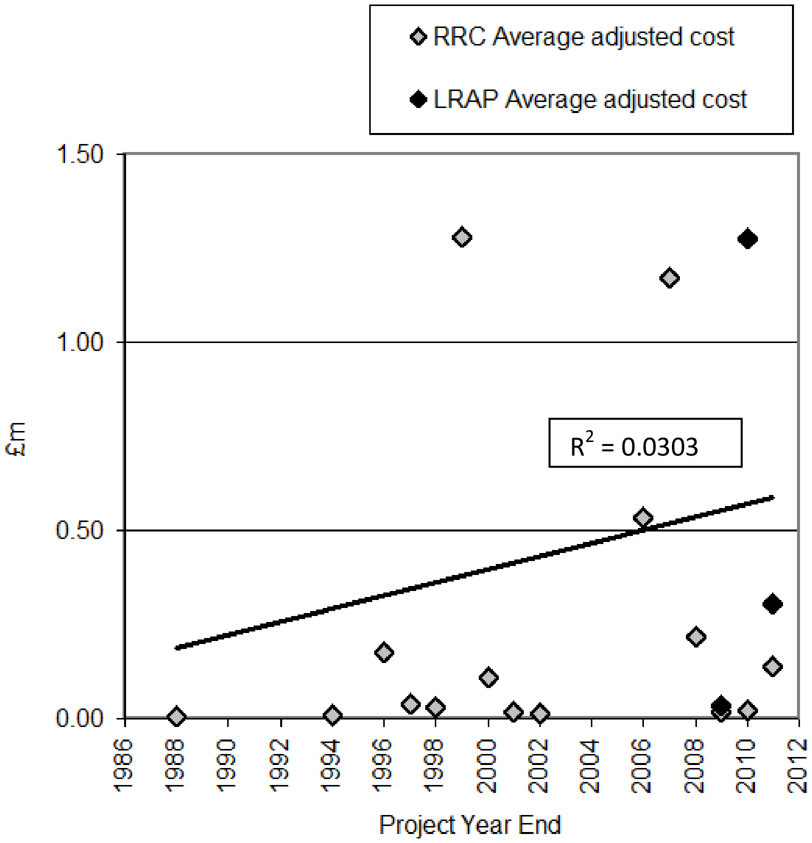


Figure 6.12 Scatterplot of annual average cost for London river restoration projects recorded in RRC and LRAP databases and adjusted for inflation, in relation to time, showing trend line and R^2 value.

6.3.5 London river restoration data: review of trends

Analysis of pre-2000 national RRC data by Bruce-Burgess (2004) found that, compared to other parts of the country, the Thames region had a high level of restoration. This was thought to be due to (i) higher levels of interest in restoring the heavily impacted urban rivers in that region, and also (ii) the proximity and support of the RRC (located in Bedfordshire).

By focusing upon the Greater London area, the present analysis has been able to demonstrate the priorities for urban river restoration within this region as biodiversity, community demand, fisheries and flood defence with increased levels of community demand recorded within the LRAP database. The majority of projects are motivated by 3 to 4 objectives which are likely to represent a combination of environmental and social goals. The data retrieved from the RRC and LRAP showed some limitations for analysis, mainly due to gaps within data fields but also the integrated nature of many projects, which included river restoration works within wider park rehabilitation.

Partnerships recorded in the LRAP database include up to 9 different organisations, of which, up to 5 may be funding organisations (Figure 6.8). Although gaps within the data prevented a more robust temporal analysis of partnerships and funding structures, analysis of the annual average total cost of urban river restorations recorded in the RRC and LRAP databases suggest higher levels of the average annual total cost per project since the late 1990s, which is calculated as over £1m in four years between 2003 and 2010 (Figure 6.11).

Analysis of the data provided several useful indications of the trends for urban river restoration partnership structures and funding regimes for recent (post-2008) and older (post-1983) projects. In particular the data reveal that significant numbers of projects are driven by biodiversity and access and recreation objectives and that, secondary to QUANGO funding, London river restoration works are often enabled by nearby developments through ‘planning gain’ or Section 106 funding contributions to project budgets.

6.4 Policy into Practice: Individual case studies

This section reports the findings of a desk study into the histories and governance context for the completed restoration case studies on the rivers Pool (6.4.1), Brent (6.4.2), and Ravensbourne (6.4.3), presented in reverse chronological order. Background information for the main case study on the Mayes Brook (6.4.4) is then presented, setting the scene for the evidence based investigation of the partnership structures, objectives and funding for this case study, presented in Chapter 7.

For each site, a brief description is provided of (i) the catchment, river and environmental management histories; (ii) the objectives for restoration as stated in the project (or other grey) literature. For the three completed projects, these are compared to (iii) the post-restoration outcomes (based on site observations and Urban River Survey assessments performed in 2009) and future outlook for the integrated management of each river. It is important to note that more detailed social investigation into local perspectives on the completed park and river outcomes were beyond the scope of this research.

6.4.1 River Pool restoration, Bell Green Gas Works

6.4.1.1 Catchment and river character and management issues

The River Pool rises in two locations, near to Shirley and West Wickham in the London Boroughs of Croydon and Bromley, and flows for 5.1 km through a heavily urbanized catchment including several culverted sections before its confluence with the river Ravensbourne in Catford, SE London. The River Pool case study reach (NGR: TQ369718) lies close to the historic site of a coal gas works at Bell Green, Sydenham in the London Borough of Lewisham (LBL). The Pool was culverted below ground level the mid-1800s (Howes, 2000) as the natural course of the river, which ran across the gas works site, was found to interfere with site operations. After over 100 years of operation (during which waters from the Pool were used for cooling) Bell Green Gas Works ceased production in 1969 (Contract Journal, 1994). Site development during the 1990s provided the opportunity for river restoration works and the Pool was reinstated at ground level or ‘daylighted’ in 1994.

6.4.1.2 Objectives for restoration

As part of the site redevelopment during the 1990s, the river channel was relocated to the east of the gas works site. Restoration works included the creation of a new ‘River View Walk’ along the Pool including a low concrete berm providing easy access to / from the channel. During the planning stages, ‘hotspots’ of ground contamination, including heavy metals, coal tar, sulphates and sulphides were discovered (Contract Journal, 1994). As a result, the priority for the channel designers was to manage the risk of transferring toxic contamination within the gasworks site to the river and potential biological receptors (aquatic organisms and humans). To ensure that there would be no negative impacts to water quality or biodiversity due to pollution entering the river, the rehabilitation solution was to combine concrete bed and bank reinforcement with a sinuous planform design (Figure 6.13). Local geology included underlying London clay, alluvial river terrace gravels and ‘made ground’. To prevent infiltration from the site, a groundwater collection system was installed by contract engineers, Amec. Partly due to the land contamination issues, the combined costs of the remediation and river restoration were reported as £5.6m (Contract Journal, 1994).

At the time of the restoration, a local group, the Sydenham Society, were highly focused upon objections to the development proposals for the main site, which included a hypermarket and large car park. Their objections were unsuccessful and plans went ahead, and there is no report of their views upon the river works (Sydenham Society, 2009).

Figure 6.13 View of River Pool case study reach at Bell Green Gas Works

6.4.1.3 Post-restoration outcomes and future outlook

Drawing upon the results of the URS assessment reported in Chapter 4, section 4.6.1.4, the present condition of the site indicates that natural river functions are redistributing the sediments within the new channel, providing increased habitat diversity and modest channel narrowing which is also improving the hydromorphological diversity. However, the heavy engineering of the bank sides remains a constraint to rehabilitation potential as full connectivity with the floodplain cannot be reinstated due to the risks associated with the land contamination. Despite the limits to the environmental recovery at this site, macrophyte and in-channel geomorphological diversity reflect some degree of dynamism and create aesthetic qualities. Observations of high levels of social usage of the adjoining park (dog walkers, family groups, paddling, sitting by the river, fish spotting) indicate that the park is well used and enjoyed by the local community. Plans outlining a Public Art Strategy for Bell Green developed under the 2006 section 106 agreement resulting from the site development, involve a proposed installation of a

‘Reed Bed’ sculpture drawing upon observations of the ‘River View Walk’ and are due for completion in 2010 (LB Lewisham, 2008).

The publication of the Ravensbourne Catchment Restoration Strategy (LB Lewisham, 2010) and £4m development of the Waterlink Way, from Bell Green to Deptford Creek in 2010/11 (funded mainly by the London Development Agency), indicate that catchment scale strategies are currently driving management of this river.

6.4.2 Brent River Park Restoration, Tockyngton Park

6.4.2.1 Catchment and river character and management issues

The river Brent rises (in the London Borough of Barnet) as the Dollis Brook in Barnet Gate Wood, from a ridge of chalk overlain with patches of gravel, sands and London Clay. Several other tributary streams in the area contribute to the flows in the upper catchment, including Deans Brook, Clitterhouse Brook, Mutton Brook and Silk Stream.

During the 1830s and upstream section of the Brent was impounded, forming the Welsh Harp reservoir, approximately 3km upstream of the restored reach, located at Tockyngton Park in the London Borough of (LB) Brent (NGR: TQ198846). Regulated releases from the reservoir impact heavily upon the natural hydrological regime of the river, generating an unnatural base-flow pattern, whilst the urban catchment drives a flashy flood response within the channelized river (Figure 6.14). While an investigation of the hydrological restoration of the Brent was beyond the scope of this research. The range of flows demonstrated by the hydrograph and observation of a range of habitat features at the restored case study site indicates that the variation in flow regime is sufficient to support geomorphological functionality (Clifford, 2007) and habitat diversity.

6.4.2.2 Objectives for restoration

The £1.37m rehabilitation of the Brent at Tockyngton Park was completed in 2003 and involved the realignment of the heavily engineered (straightened, fully reinforced) river channel into a new meandering, lightly reinforced planform. The project included the overall enhancement of the surrounding park to improve its amenity value and included physical features specifically designed to link communities on each side of the river, e.g. a new bridge and play area. The river restoration itself represents a ‘soft engineering’ approach whereby vulnerable sections of bank have been stabilised using a combination of crushed concrete buried within the banks and gabions, in combination with willow spiling.

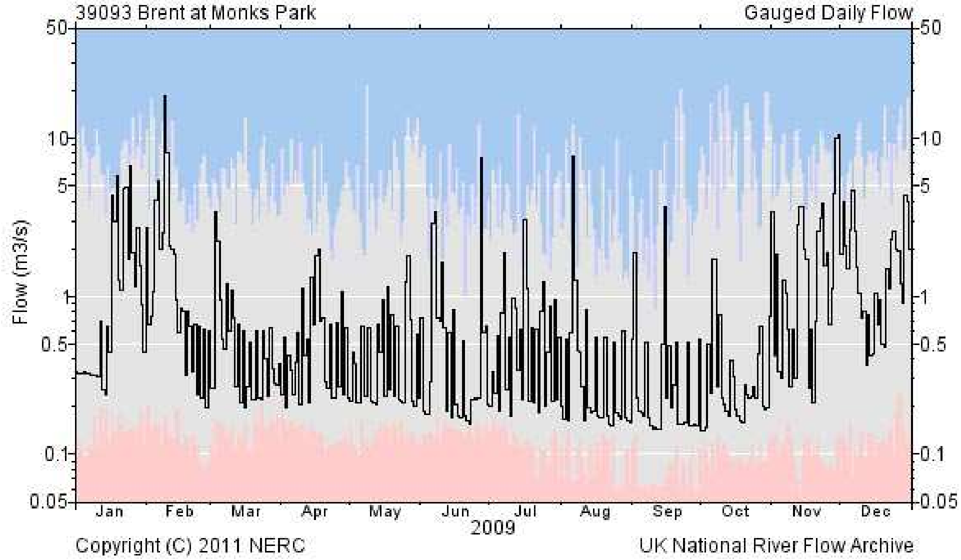


Figure 6.14 Hydrograph of Brent River Flows, between Welsh Harp Reservoir and Tockyngton Park. Source:CEH (www.ceh.ac.uk/data/nrfa/data/time_series.html?39093)

Local consultation took place over three phases and using a variety of techniques during the pre-works period from 1999 to 2002. These included questionnaires (with freepost reply envelopes); focus groups; information leaflets; display of plans in public buildings; public meetings; individual group briefings to local business and local government representatives; a ‘Planning for Real’ exercise whereby a scale model of the site was used to facilitate and encourage local discussion. Local groups included Friends of Brent River Park and Brent Youth (previously Brent Millennium Volunteers) other groups supporting the project included Groundwork, River Restoration Centre; Thames 21 and Safer Waterways for London. The major funding for the project was secured from the EU (Objective 2 programme); other contributors included the London Waterways Partnership, London Development Agency, Brent Council Neighbourhood Renewal Fund, Brent Capital Programme and the EA (Mbeke, 2008).

The river forms the boundary between two wards: Tockyngton to the west and Stonebridge to the east. Differences in socio-economic factors for each ward are summarised in Table 6.5 (as percentages) using 2001 census data (Office of National Statistics, 2001, http://neighbourhood.statistics.gov.uk/dissemination/).

Table 6.5 Social statistics for the adjoining wards to Brent River Park Restoration Project (Source: http://neighbourhood.statistics.gov.uk/dissemination/)

WARDS	2001 CENSUS DATA				Index of Multiple Deprivation (IMD) Rank 2004
	Pop density (pers/ha)	Owner/ occupiers	Tot economically active	Tot limiting long term illness	
Tockyngton	42.8	70.9	56.4	16.2	13109
Stonebridge	39.3*	26.8	46.5	16.8	3920**

* These figures do not reflect the 1991 density of the area (previously known as St Raphael's Ward – 61.3 pers/ha) as the two wards were merged.

* * Stonebridge is defined as an area of high deprivation: for over a third of the Super Output Areas (SOA) in Stonebridge fall into the 10% most deprived category based on the Index of Multiple Deprivation, (http://www.brent.gov.uk/demographic.nsf/)

6.4.2.3 Post-restoration outcomes and future outlook

The bio-physical assessment of the ecological condition of the river at Tockyngton Park, undertaken using the URS methodology and presented in section 4.6.1, indicates considerable recovery of river form and function where restoration works were carried out. Ongoing events organized by the main project manager with the London Borough of Brent continue to provide a focal point for community activity, building cohesion between the ward estates on each side of the river. Evidence from research interviews with the EA and the LB Brent, and observations of one community event suggest that the dedication of a key actor in the local authority appears to be a driving force behind the social engagement and continuing community involvement. Factors of concern for local residents include non-resident groups using the park for anti-social activities including alcohol consumption, resulting excessive littering and noise.

A report on the influence of the river restoration project on social cohesion in the neighbouring areas (Mbeke, 2008) found that the project offered a valuable focal point for communities previously separated physically by the river. It noted that the restoration alone could not enhance community cohesion; however, the project provided a positive starting point which offered many opportunities for key actors to bring communities together; to raise awareness of the benefits of the project to individuals and the wider community; and to build cooperation and cohesion around their shared open space.

Work by the EA Conservation Officer for the Brent to establish a Brent Catchment Partnership group linking adjoining local authorities (Brent, Barnet, Ealing, Hounslow and Harrow), British Waterways, Thames 21, Groundwork and Thames River Restoration Trust is ongoing. Several of the partners are already delivering small scale plans for clean ups, minor rehabilitation works and community events and installations to raise awareness of the river system and wider environmental issues concerning biodiversity, climate change and SUDS e.g. ‘C-Change’ project at Brent River Park, www.cchangeproject.org/gwk. Catchment scale co-ordination of environmental activities is ongoing, however the local interest group, the Brent River and Canal Society has not been as active in this catchment when compared to others such as those in the Wandle and Ravensbourne-Quaggy catchments, and further socio-economic investigation might usefully shed light on the underlying causes and encourage greater stakeholder participation.

Parallel initiatives in progress to further improve the River Brent include investigations into the misconnections within the catchment by Thames Water (Carthy, Thames Water, Interview comments, 2010); and development on the All London Green Grid by Design for London. The need for an integrated catchment management plan, extending across the borough boundaries is recognized by the EA and in the early stages of development.

6.4.3 River Ravensbourne restoration, QUERCUS

6.4.3.1 Catchment and river character and management issues

The river Ravensbourne flows north from its source at Caesar’s Well in Keston, London Borough of Bromley, Kent to the tidal reaches of Deptford Creek before its confluence with the river Thames. The Ravensbourne catchment covers an area of 180km and includes several minor and two major tributaries (R. Pool and R. Quaggy). The public open space of Ladywell Fields borders the river between Catford and Ladywell, upstream of the river’s confluence with the Quaggy at Lewisham town centre.

Early development of the Ravensbourne dates back to the 11th century and includes mills, gravel-pits, and ship building. Industrial development continued to impact the river through gasworks, breweries and chemical works. Although the upper reaches remained agricultural, urban areas downstream were affected by flooding and a mobile channel (LB Lewisham, 2010). Flood engineering accompanying rapid urban development during the early 1900s and after flood incidents in 1960s resulted in further extensive over-widening, reinforcement and culverting of the river (LB Lewisham, 2010). Since then, channel neglect in many reaches has led to decaying reinforcements and an overgrown riparian zone. Recent rehabilitation works within the catchment include restorations at Manor Park and Sutcliffe Park (Quaggy branch), Bell Green Gas Works (Pool branch), and Cornmill Gardens plus minor works on adjoining reaches in partnership with residential riparian owners.

Several restoration projects and activities have been driven by local groups, for example the Quaggy Waterways Action Group in partnership with the EA. Whereas in the past these have often been piecemeal and opportunistic, increasing coordination between Lewisham council, local resident and environmental organizations, and the EA are demonstrating the benefits of integrated management strategies, e.g. the ‘3 Rivers Cleanup’ which successfully reduced populations of Himalayan Balsam from the catchment through coordinated community removal events between 2009 and 2011, (see www.qwag.org.uk/3riverscleanup/).

6.4.3.2 Objectives for restoration

The Ravensbourne restoration project at Ladywell Fields north was completed in 2008 as part of the EU Life funded Quality Urban Environments for River Corridor Users and Stakeholders (QUERCUS) project (www.quercus-project.eu/, LB Lewisham, 2009). A summary of the project stages is shown in Table 6.6. The origins of the project were catalysed in the mid-2000s by the redevelopment of Lewisham Hospital, located adjacent to the river and Ladywell Fields. An opportunity to undertake section 106 funded mitigation works plus the need to address flooding issues in the hospital basement (Webb, Biodiversity Team Leader EA, 2010, Interview comment) brought attention to the potential for rehabilitation works on the channel and floodplain in Ladywell Fields. Initial works involving the creation of an island in the existing channel were unsuccessful, however a partnership between the EA and the Ladywell Fields Park User Group led to a consultation and the development of more ambitious plans to create a new channel and flood storage within the public open space (Figure 6.15).

The support and involvement of Lewisham Council led to a successful application for funding through the EU Life fund. This required the amalgamation of three proposals in London, Chester and Holland to create the QUERCUS project. This complex tiered partnership, operating at both the European and local levels, was led by the London Borough of Lewisham from around 2006 until completion in 2008 (LB Lewisham, 2009; Woolley, 2009).

Table 6.6 Approximate time line summarizing the key project stages and influences for the QUERCUS restoration at Ladywell Fields North

Year	QUERCUS Project Stage
2002	Pre-QUERCUS: restoration of river Quaggy in Chinbrook Meadows (cost £102K) - provides visible and striking demonstration of potential for river restoration works at Ladywell Fields
2004	Pre-QUERCUS: local residents (Ladywell Fields Park User Group, LFPUG etc) identify opportunity for Ravensbourne in Ladywell Fields; contact EA to discuss potential for restoration & raise concerns about anti social behaviour in park; Initial Concept: EA hold meeting with LFPUG to share and develop ideas for 'vision'; EA produce a 'mock up' of broad options
2005	Catalyst: Regeneration of hospital site provides Section 106 funding opportunity with potential for mitigation investment
2006	QUERCUS project initiation with LB Lewisham involvement; plus application to EU Life fund (approximately 2 years after initial recognition of opportunity and contact between LFPUG & EA) in partnership with Chester and Netherlands projects
2007	QUERCUS bid successful => Dedicated Project Manager & Park Rangers appointed; Cornmill Gardens - restoration completed
2008	QUERCUS restoration of the river Ravensbourne in Ladywell Fields completed

6.4.3.3 Post-restoration outcomes and future outlook

The early stages of channel recovery at the QUERCUS case study site provide signs of positive environmental outcomes, which are demonstrated by the results of the Urban River Survey bio-physical assessment presented in Chapter 4. The URS results reflect the signs of active channel adjustment such as bank erosion, plus a relatively diverse assemblage of macrophytes which were recorded in 2009, just one year after restoration works were completed (Figure 6.16). The popularity of this river restoration with members of the local residential and hospital communities was evident during repeated site visits between 2009-2011 by the numbers observed within the park, and supports

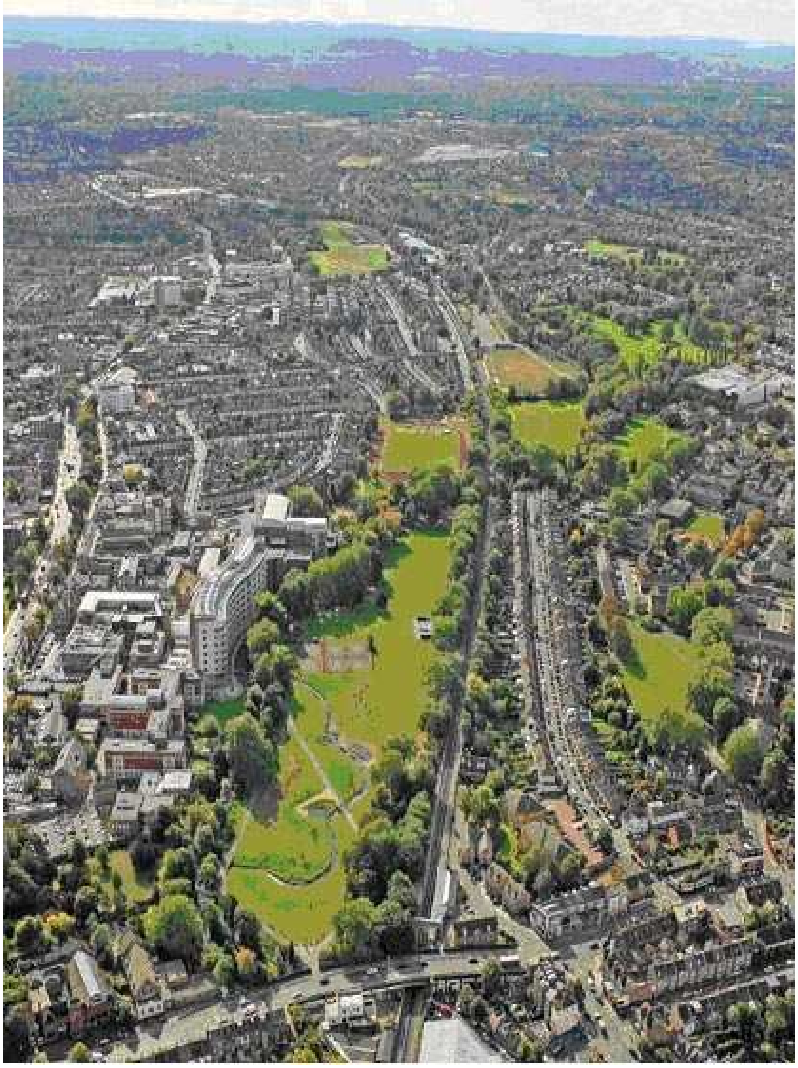


Figure 6.15 Aerial view of Ladywell fields restoration looking upstream along catchment. Source: Ravensboure Restoration Strategy, LB Lewisham 2010

Figure 6.16 View of restored river Ravensbourne at Ladywell Fields, August 2009

post-project appraisal data which demonstrate a >250% increase in park users (LB Lewisham, 2009). A significant affirmation of the positive outcomes has been the success of Lewisham Council in winning £2m from the London Development Agency to restore the adjacent upstream section of the Ravensbourne within Ladywell Fields south and the river corridor between Deptford and Sydenham (Waterlink Way) through the Thames Gateway Parklands project (LDA, 2010).

6.4.4 Mayesbrook Park Restoration Project: 'Adapting to Climate Change'

6.4.4.1 Catchment and river character and management issues

The Mayes Brook is a tributary of the River Roding, rising at an unknown location, north of Chadwell Heath in the London Borough of Redbridge. Its source is not easily identified as the whole upper catchment north of Goodmayes Park (NGR TQ467865) is fully culverted. Historic maps indicate the sinuous course of the brook, flowing south through Chadwell, past Upney into the London Borough of Barking and Dagenham (LBBD), and through the marshlands of the Barking Levels until its confluence with the Roding at Barking Creek (Figure 6.17). Geologically, much of the local borough lies on river terrace gravels (LBBD, 2007). Surface gravels observed in the soils at Mayesbrook Park and the Mayes Brook channel, confirm this composition. The brook and associated watercourses are listed as a Grade II Site of Borough importance (LBBD, 2004a).

The area around Mayesbrook Park was historically part of extensive marshlands, drained for grazing from the 12th-13th century and then used as market gardens up to the early 1900s. Rapid urban development closely followed the opening of the Barking Power Station at Creekmouth in 1925 (Vickers, 1992, Powell, 1966). Historic maps (Figures 6.17 and 6.18) suggest that channel straightening predates the 1880s and periods of 19th and 20th century development including the construction of the railway at the southern border of Mayesbrook Park, as the catchment was transformed from rural to fully urbanized (LBBD, 2007; EA, 2008).

The results of the URS bio-physical assessment of all accessible (and non-culverted) channels within the Mayes Brook catchment (section 4.5) indicate the predominance of straightened and re-sectioned or enlarged channel engineering, reinforced on either both banks or fully. The channel engineering has resulted in relatively uniform habitat with

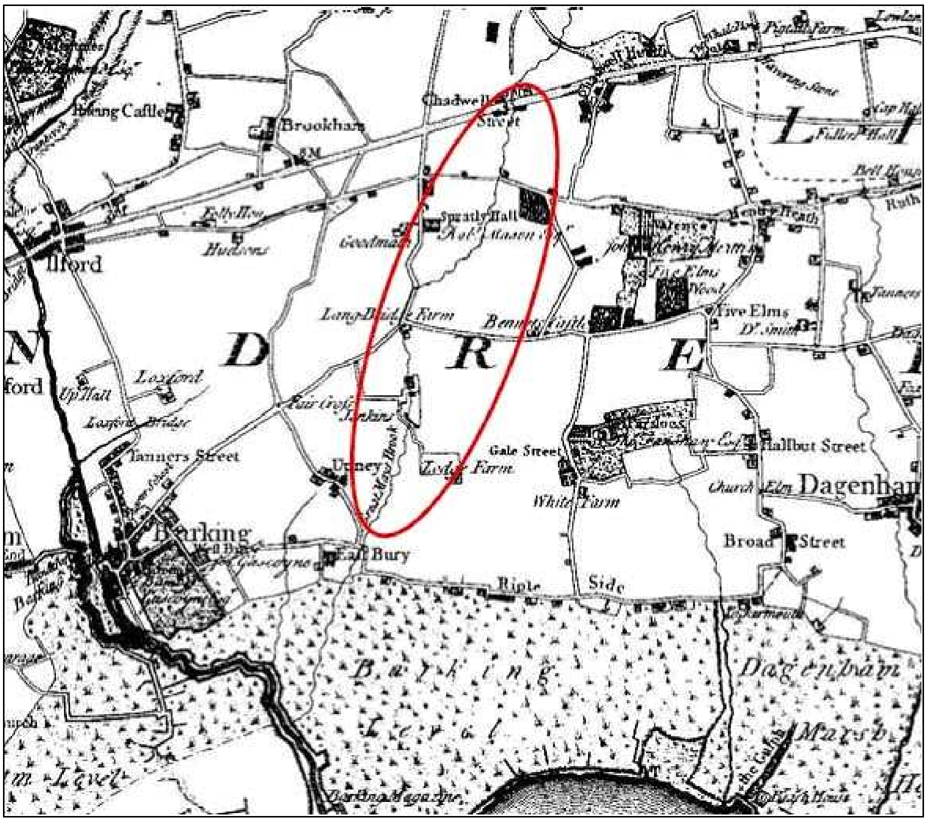
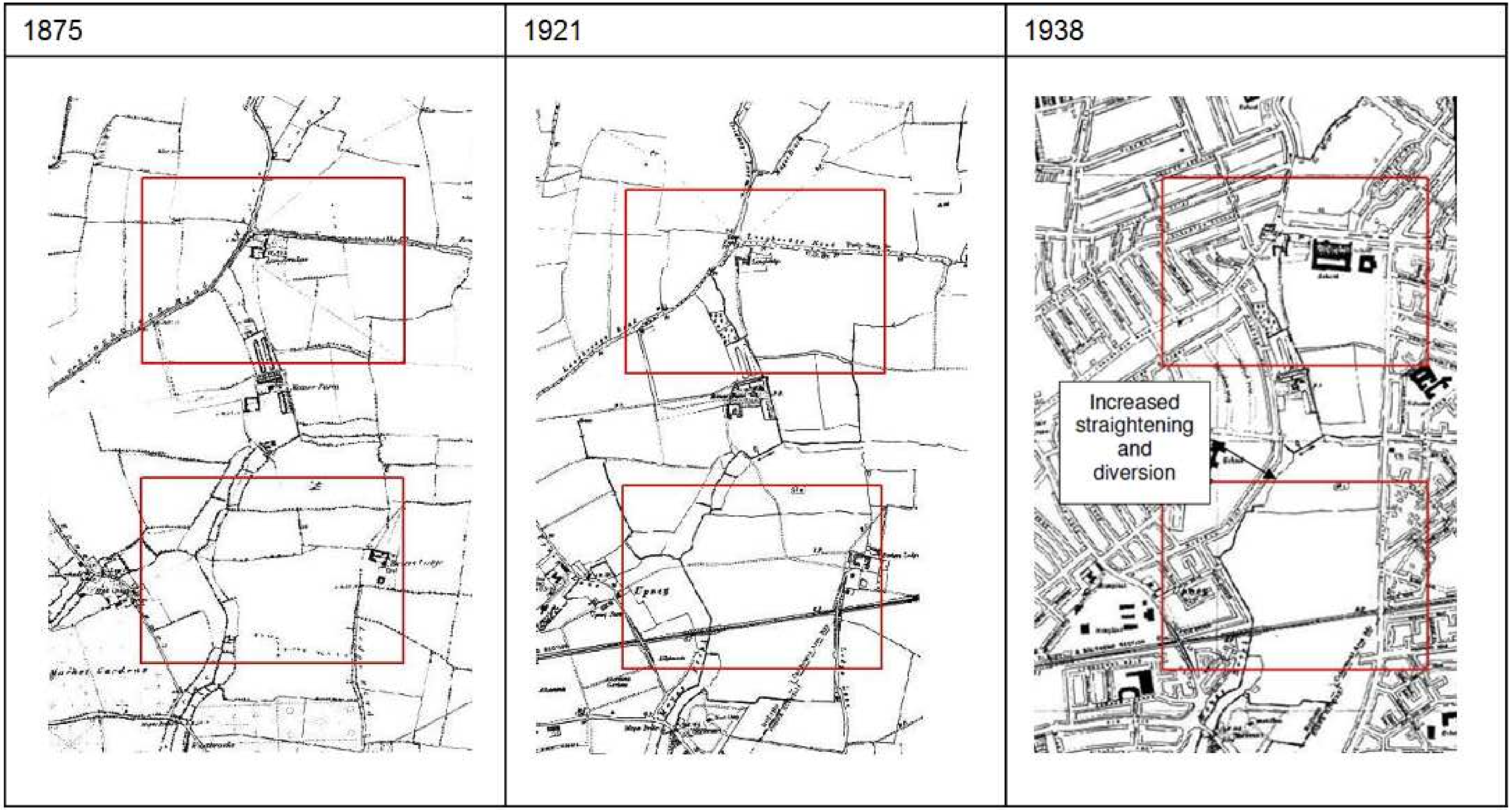


Figure 6.17 Part of 'A Map of the County of Essex' (1777) by Chapman and Andre, indicating the location of the Mayes brook between Upney and Chadwell. Adapted from: LBBD Urban Design Framework (2007, p.5)

low diversity which is reflected by the plotting positions of the survey reaches on the URS matrix (Figure 4.26) and the mainly 'Poor' or 'Very Poor' Stretch Habitat Quality Index scores for all reaches, which range from 14 to 18 (Figure 4.14).

At Mayesbrook Park, the Mayes Brook currently flows in an artificially straightened, re-sectioned and reinforced channel running along the eastern perimeter of the park within a densely developed residential area (Figure 6.19). Created in the 1930s, Mayesbrook Park provides 48.5 ha of open space and features two large lakes, originally gravel extraction pits, dating back to 1940s. The lakes now function as floodwater storage during times of high flow as a part of the EA local flood risk management strategy and are connected to the brook via a concrete lined overflow channel (Figure 6.20) and smaller discharge outlet. When high precipitation coincides with high tides, a telemetrically controlled sluice system within the brook diverts upstream flows into the lakes. The operation and maintenance of the sluice, pumps and channel are performed by the Environment Agency. Channel maintenance works also include the cutting back of macrophytes and riparian vegetation within the Mayes brook channel at flood management locations.

Figure 6.18 Three frames showing the course of the Mayes Brook as depicted on historic maps dating from 1875 to 1938. Source: Mayes Brook restoration scoping report (EA, 2008)



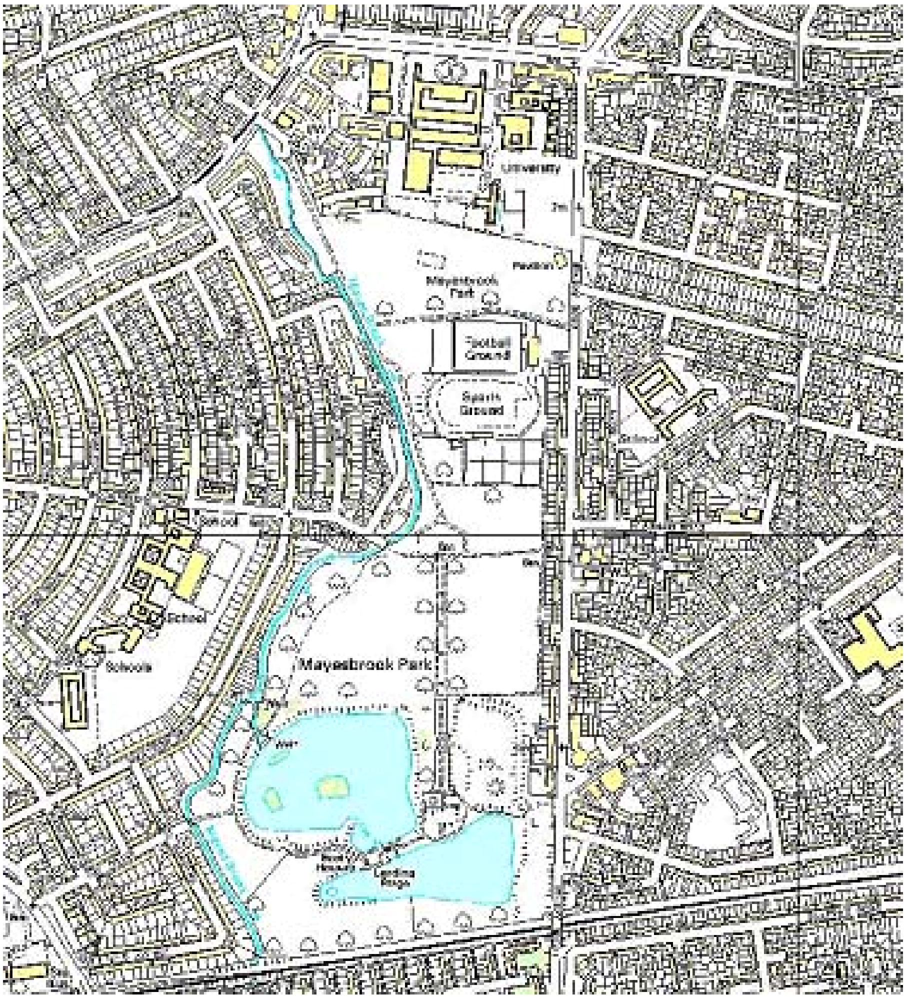


Figure 6.19 1:25 000 Map of Mayesbrook park and surrounding areas. Source: Mayes Brook restoration scoping report (EA, 2008).

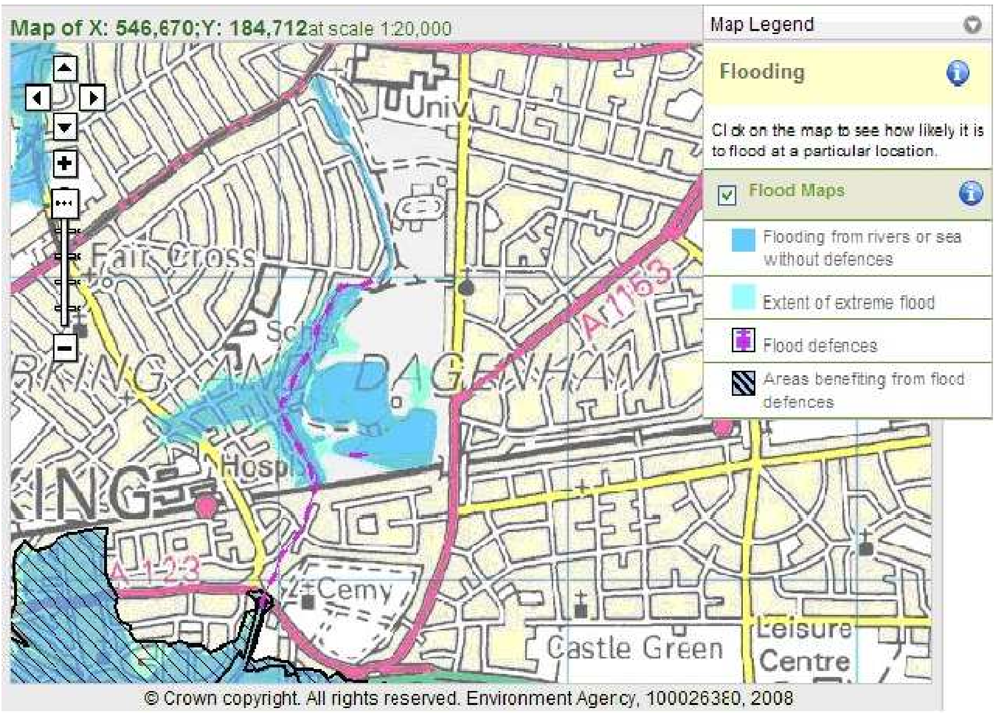
Figure 6.20 Two views of the flood management system at Mayesbrook Park: showing (a) the overflow channel between Mayesbrook and the lakes and (b) the flood sluice gate.

6.4.4.2 Objectives for restoration

The brook at Mayesbrook Park is described as having ‘low ecological interest’ and was identified by the EA for restoration as a potential demonstration site for the London Rivers Action Plan (LRAP, EA et al. 2009). At the same time, regeneration plans for the park, in development by LBBD as part of local urban regeneration initiatives, also identified Mayesbrook Park as a potential site to link with other greenspaces in the borough, building stronger local neighbourhood connections to Goodmayes Park immediately to the north and Barking Creek to the south. These aims were brought together through the creation of a partnership to deliver an integrated climate change adaptation focused project: to restore the river and wider park environment, to create flood storage areas, increased biodiversity and greater opportunities for local people to benefit from the improved local greenspace. Restoration objectives coincided closely with policy initiatives for the partners, including the Environment Agency (North London River Strategy; London Rivers Action Plan), Natural England (Natural Connections; Access to Nature; urban greening), Greater London Authority (Mayor’s London Plan, Climate Change Strategy; Priority Parks Strategy), and links to the LBBD Parks and Green Spaces Strategy (ELGG Area Framework 2, Davidson et al. 2007).

The flood management operations, including the sluice and lakes system at Mayesbrook Park and flood storage areas further downstream provide a high level of protection from the combined risks of fluvial and tidal flooding to the local area. However, a residual risk to properties adjoining the park remains (Figure 6.21). In view of the high costs of managing the sluice system, the creation of a new flood storage area within the park supports a longer term more sustainable approach to managing flood risk in the area. The additional risks posed by climate change and described by the UKCIP02 projections within planning policy guidance PPS25 of increased precipitation and river flows (DCLG, 2010) also provide a key driver for partners and defined the over-riding objective of the project as a demonstration park for climate change adaptation.

The Mayesbrook Park project masterplan illustrates the main components of the planned rehabilitation works including the creation of a new sinuous unconstrained channel through the floodplain area immediately upstream of the flood storage lakes (Figure 6.22). Earthworks, originally planned for 2010, began on site in April 2011. Detail of the project time line, including delays and dynamics of project implementation are provided in Chapter 7 (section 7.3.1).



Map of X: 546,670;Y: 184,712at scale 1:20,000

Map Legend

Flooding

Click on the map to see how likely it is to flood at a particular location.

☑ Flood Maps

🟦 Flooding from rivers or sea without defences

▢ Extent of extreme flood

▯ Flood defences

▨ Areas benefiting from flood defences

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Figure 6.21 Environment Agency Flood Risk Map for Mayesbrook and surrounding areas. Accessed: August 2009.

Following restoration of the reaches adjacent to Mayesbrook Park, post project appraisals, including further assessment using the URS method will form part of an adaptive management plan for the new Mayes Brook channel. It is expected that future URS results will show a trajectory of change via the plotting positions of the new channel surveys which will reflect changes in bio-physical condition associated with the engineering works and subsequent recovery of the channel, as well as any responses to climatic events.

Figure 6.22 Masterplan document: Design of new brook channel and surrounding parkland. Source: Quartet Design, 2009c.

6.5 Conclusions: Restoration practice – a London overview

This chapter has examined the information resources available to river restoration practitioners and management characteristics of London river restoration projects through a selection of historic and recent data.

The data presented in Chapter 5 demonstrate the high level of policy support for the restoration of aquatic environments and the case studies demonstrate how these policies are enabling the delivery of a wide range of environmental and human benefits through integrated projects whilst aiming to meet the requirements of the WFD and sustainable development agendas. Increasing responsibilities for Local Authorities to manage flood risk within their administrative boundaries also generates a need for increased knowledge and support to coordinate catchment-coherent flood risk management strategies. Where such approaches identify river restoration as a solution, sharing knowledge of how to successfully integrate and streamline objectives will save resources and make delivery more efficient for non-river experts, and increase the probability of achieving the best possible environmental outcomes. Online environmental information systems and directories of case studies, such as those provided by the RRC and LRAP therefore provide valuable resources for non-technical practitioners.

The insights provided by the London case study restoration scenarios along with the information extracted from the RRC and LRAP databases, together provide a context for a detailed investigation of the planning and delivery of the main case study at Mayesbrook Park. The contrasting scenarios described through the case study data (summarised in Table 6.7) reflect the diversity of projects delivered within London. As for any aquatic environment, urban rivers provide unique combinations of natural and anthropogenic environmental and social components. However it is the additional complexity and density of anthropogenic and social factors within urban catchments that make such environments particularly challenging to sympathetic management.

The sequence of restoration practice demonstrated by the case study timeline reflects not only the unique circumstances of each restoration, but also the differences in approach to remedial solutions. The evidence presented in this chapter allows tentative links to be made between the RRC/LRAP data and case study management histories which each indicate a shift towards community engagement. The timeline also

Table 6.7 Summary of main objectives and characteristics of case study river restorations

River, Location (Borough)	**Project name**	**Project completion**	**Restoration objectives[1]**	**Restoration type**	**Funding**	**Social survey**
Pool, Bell Green Gas Works (Lewisham, LBL)	Bell Green Gas Works	1994	Biodiversity; Amenity	Daylighting; Restoration	(EA, Local Development)	
Brent, Tockyngton Park (Brent, LBL)	Brent River Park Restoration Project	2004	Flood risk management, Social cohesion, Green infrastructure; Biodiversity; Amenity To improve public access to the river; connect communities on both sides of the river; reduce crime, engage community in nature conservation & environmental studies. (LRAP xls)	Restoration	SRB, EA, LBB	MSc project Cranfield University, 2008; MSc project QMUL, 2009
Ravensbourne, Ladywell Fields North (Lewisham, LBL)	Quality Urban Environments for River corridor users and stakeholders (QUERCUS)	2008	Green infrastructure; Biodiversity; Amenity; Designing out Crime To increase use and enjoyment of Ladywell Fields and the River Ravensbourne; to reduce crime and fear of crime in the project site; and to improve habitats for wildlife. (RRC xls)	Creation	EU Life; LBC; EA, S106	Park user surveys; schools (ongoing) Evaluation of QUERCUS process (Woolley, 2009)
Mayes Brook, Mayesbrook Park (Barking and Dagenham, LBBD)	Mayesbrook Park Restoration Project: Adapting to Climate Change	2011	Habitat; Fisheries; Community demand; Landscape Natural flood storage, climate change adaptation, green infrastructure; biodiversity, amenity.	Creation; restoration	EA; NE; GLA; LBBD; SITA; RSA; TRRT	Park user survey, February 2009

[1]As specified by LRAP / RRC spreadsheets (Accessed 2011)

illustrates the technical changes in engineering towards softer more experimental approaches, with an emphasis on lateral connectivity.

In the case of the river Pool, here different priorities relating to the land contamination, were inevitably driving the design at a high level. The river Pool restoration prioritised the management of the source:receptor pathway by effectively preventing recruitment of contaminated floodplain sediments. However, the introduction of in-channel concrete embayments acting as ‘planters’ to control the location of marginal planting marks a sharp contrast to current approaches to in-stream interventions. For this restoration, anecdotal evidence supports the hypothesis that a contemporary approach would have taken a different path (Webb, EA personal comment, 2010), leading to the creation of more natural river margins and allowing greater adjustment of introduced bed materials even within an enlarged containment channel.

In this respect, the historic restoration style is characteristic of the time and the prevailing dominance of hard engineered solutions as demonstrated by the smooth concrete margins, fixed ‘planters’, homogeneous depth, channel constrictions and lack of emphasis on lateral connectivity. Recent transitions towards the use of soft engineering, and in-channel flow deflectors or pinned large woody debris are increasingly designed to promote the creation of marginal features and bed heterogeneity, demonstrating greater understanding of fluvial geomorphological processes and role of large woody debris in the creation of diverse functional habitat (Gurnell et al. 2002, Abbe et al. 2003, Montgomery et al. 2003).

Similar transitions towards allowing greater lateral connectivity (on uncontaminated sites) are demonstrated partially on the river Brent (at Tockyngton Park) but most explicitly by the river Ravensbourne (QUERCUS) restoration where the newly created channel was ‘under cut’ in order for natural processes to develop the channel form and habitat features. For this most recent example on the restoration time line, less was done to try to ‘fix’ the river either in terms of position or in-channel features which are allowed to develop through ‘naturalised’ river functions where possible.

Further contrasts in the social dimension are demonstrated along the restoration time line: from the limited evidence of stakeholder engagement during the river Pool restoration planning stages, compared to the considerable levels of local involvement demonstrated by the Brent and Ravensbourne case histories. Again, high levels of local participation in the design of the Ravensbourne (QUERCUS) restoration from the early planning stages reflected local awareness of the transformative potential of river restoration works, already witnessed elsewhere in the Ravensbourne catchment, and advocacy by key individuals within the community. At the Brent and Ravensbourne restoration sites, continued participation in river and riparian clean up events demonstrate ongoing commitments by river managers and nearby communities to maintaining the quality of their restored river environments. These differences also reflect the increasing levels of investment in social engagement by the Environment Agency and Local Authorities, as key individuals recognise the importance of the social factors in sustainable urban catchment management.

In Chapter 7, further socially-focused research aims to shed additional light upon the processes of multi-disciplinary partnerships involved in urban river restoration and their role in planning and financing and delivering integrated urban river restoration projects both at the reach scale and in the context of long-term sustainable catchment management.

Chapter 7: Results IV – An investigation of the Environmental Governance of Urban River Restoration in Greater London

7.1 Introduction

The purpose of this chapter is to investigate the characteristics of environmental governance associated with the delivery of urban river restoration in London, and in particular, the extent to which multi-disciplinary partnerships are successful in planning and delivering ecologically beneficial and cost-effective improvements to urban rivers through integrated urban river restoration projects.

The literature reviewed in Chapter 2 described the increasing integration of river management styles over the last twenty years, towards the inclusion of ecosystems approaches and sustainable development principles. However, a range of management challenges for urban rivers remain, often focused around the diverse perspectives and understandings of rivers and river management (Pickett et al. 2001; Downs and Gregory, 2004, Clifford, 2007; Holt, 2009). These challenges are particularly relevant in urban catchments where concentrated anthropogenic impacts are most damaging. At the same time potential improvements in environmental quality and ecosystem services associated with river restoration works may offer a wide range of benefits for aquatic and human communities inhabiting otherwise heavily developed urban landscapes.

The varied perspectives of multi-disciplinary stakeholders and associated ‘visions’ of river-floodplain-park restoration or rehabilitation options may lead to a wide variety of proposals for restoration-regeneration objectives and potential outcomes (Gregory and Brierley, 2010). In this context, new interpretations of environmental quality in terms of *ecological condition* (i.e. ‘status’ or ‘potential’ depending on degree of channel modification) under the EU Water Framework Directive (WFD, EC, 2000), or *ecosystem services* to society, as defined by the Millennium Ecosystem Assessment, (MA, 2005a) offer opportunities to find common ground between diverse partners and increase support for river improvement projects (Everard, 2011).

This chapter presents the findings of case study research, including (i) observations of steering group meetings for the main case study: the Mayes Brook and Mayesbrook Park Restoration Project (MPRP) in the London Borough of (LB) Barking and

Dagenham; (ii) additional meetings relating to the other case studies (River Ravensbourne at Ladywell Fields, Quality Urban Environments for River Corridor Users (QUERCUS) project, and the Brent River Park Restoration Project, BRPRP); and (iii) findings from twenty-one interviews with river practitioners involved in the case studies or related initiatives. These data sources enabled a thorough investigation into the processes of planning and project managing urban river restorations in contrast to the environmental outcome assessments investigated in Chapter 4.

The introduction provides an overview of the data by summarising the emerging themes from the interview analysis (section 7.1.1) and a brief analytical overview of the interviewee distribution (section 7.1.2) to introduce the London river restoration project management context underlying the research findings presented in this chapter. Section 7.2 begins with a summary of the river channel management challenges of relevance to London rivers (Downs and Gregory, 2004; EA, unpublished, 2011) and considers these in relation to the characteristics and processes of partnerships (Mackintosh, 1992; Bailey et al. 1995) (section 7.2.1). Section 7.2.2 then investigates how the structures and networks observed within the MPRP partnership relate to partner roles, sectors and disciplinary backgrounds.

Section 7.3 uses partnership life-cycle theory (Lowndes and Skelcher, 1998) to shed further light upon urban river restoration planning processes through a comparison with the MPRP case study project timeline and interview data (section 7.3.1). This enables evaluation of the observed progress of the MPRP programme in relation to internal partnership and management processes. The significance of time scales to urban river restoration planning and development is investigated further in section 7.3.2, in relation to external environmental and social time factors. This section explores the impacts of temporal discontinuities and partner expectations upon restoration planning progress.

In section 7.4 the evidence for resourcing and funding practices for urban river restoration projects are reviewed. Analysis of the MPRP case study data is compared to the results of the RRC/LRAP data analyses presented in Chapter 6 and the other case studies. This section reviews the financial planning strategies of the case studies in relation to project time management (section 7.4.1). A closer examination of the complex MPRP funding package is then investigated and evaluated in terms of the influence of funding agreements upon partnership dynamics and urban river restoration outcomes (section 7.4.2).

Lastly, section 7.5 brings the focus of the chapter back to the primary objectives of the thesis through an investigation of the evidence for environmentally beneficial outcomes and the ways in which multi-disciplinary partnership may achieve beneficial outcomes for urban river environments and enhanced ecosystem services. The chapter closes with an overview of how the qualities of partnership, introduced in section 7.2 may contribute towards meeting the management challenges for urban river restoration projects.

7.1.1 Data review: emerging themes

Data gathered through observations of the MPRP steering group (and other meetings) plus 20 actor interviews (summarised in Chapter 3, Tables 3.13 and 3.14), together provide the main body of evidence used to identify the key issues arising from current urban river restoration governance practices in Greater London. Coding analysis of the interview data was carried out manually and using nVivo software (described in section 3.6.3) to facilitate the identification of the main emerging themes for London river restoration practitioners and partners. While these analyses in part reflect the author’s learning curve and interpretation of an unfamiliar method, they provided many valuable insights to the issues raised by interviewees. Due to the multi-disciplinary extent of this research, time constraints prevented a full empirical analysis of the interview and meeting data. However, an overview of the main emerging themes and subthemes, provided in Table 7.1, illustrates the scope of the data and analyses presented in this chapter. The values in this table illustrate the extent to which themes and sub-themes were identified within the source material. As it is possible to generate multiple codings from individual references, the reference counts are only weakly indicative of the balance of data contributing towards the main themes of Governance, Partnership, Objectives and Resourcing, which are developed through this chapter and Chapter 8.

7.1.2 Data review: interviews

For practical reasons, manual coding only was undertaken for the meeting observation data (summarised in Table 3.13). The summary of the interviewee distribution shown in Table 7.2 indicates the different types of organisation (and perspectives) represented through the case studies (and other project) interviews. The lower section includes a more detailed breakdown of the MPRP interviewees by sector and partnership role.

Table 7.1 Counts of references to emerging themes and sub-themes identified within interview data, using nVivo coding analysis.

Main theme	**Sub-theme**	**Reference counts**
Objectives		**130**
	River function and ecological condition	33
	Integration of environmental and social	20
	Human quality of life and health	13
	Climate change adaptation	13
	Biodiversity and habitat	13
	Ecosystem services approach	5
Governance		**114**
	Partnership and networks	217
	Individual roles	157
	Stakeholder engagement, localism	114
	Institutional roles	114
	Bureaucracy and hierarchies	96
	Policy drivers and development	41
	Multi- and Inter-disciplinary connections	22
Decision Making		**18**
	Context, catalysts and connections	82
	Facilitation and liaison	63
	Social factors	40
	Technical factors	32
	Spatial scales	21
Resourcing		**88**
	Internal/External Funding and Finance	132
	Time Scales	67
	Flexibility	28
	Conditions	15
	Human resource	7
Challenges		**10**
	Tensions and power dynamics	93
	Obstacles to progress	66
	Obstacles to communication	46
	Complexity	45
	Issue weighting	25
	Expectation management	5
Positive outcomes		**38**
	Knowledge exchange	125
	Creating new opportunities	44
	Social gains	31
	Solutions to challenges	26
	Ecological gains	7
	Recommendations	7

Most interviews were carried out with partners representing QUANGOs, reflecting the prominent roles of the Environment Agency (EA) and Natural England (NE). An under-representation of civil society within the interview sample is evident, mainly because the primary research focus was upon governance and therefore concentrated primarily on steering group partners and organisations, although other factors contributing to the balance of sectors represented are also indicated within the analysis.

Table 7.2 Distribution of interviewees and break down of roles by sector for MPRP case study.

Case study / Regional focus	**Public**	**QUANGO**	**Non-Profit**	**Civil**	**Private**	**TOTAL**
MPRP (Mayes Brook)	2	5	2	0	3	**12**
QUERCUS (Ravensbourne)	2	1	0	1	0	**4**
BRPRP (Brent)	0	1	0	0	0	**1**
Regional/other	1	1	1	0	0	**3**
TOTAL	**5**	**8**	**3**	**1**	**3**	**20**
Mayesbrook Park Restoration Project - Steering Group Interviewee Roles						
Interviewee role	**Public**	**QUANGO**	**Non-Profit**	**Civil**	**Private**	**TOTAL**
Project / finance management /	1	1	0	0	0	**2**
Sponsor	1	2	1	0	1	**5**
Advisory	0	2	0	0	1	**3**
Delivery	0	0	1	0	1	**2**
TOTAL	**2**	**5**	**2**	**0**	**3**	**12**

7.2 Multi-disciplinary partnerships and urban river restoration in the context of Greater London

This section examines in detail the partnership processes involved during the planning and delivery stages of urban river restoration, in relation to environmental objectives for urban rivers and aquatic environments. Case study evidence is used to gain an understanding of the structures and processes of multi-disciplinary partnerships and how partners work together to plan and deliver urban river restoration. The discourses around environmental governance introduced in section 2.3 provide the context for the results presented within this section. In particular, theories of partnership (Mackintosh, 1992; Bailey et al 1995) and partnership life-cycle (Lowndes and Skelcher, 1998) are considered in relation to the management challenges and issues for London rivers, and underpin the investigations of the case study evidence reported in this section.

7.2.1 Management context for London rivers and partnerships

At the July 2011 meeting of the London Rivers and Streams Habitat Action Plan steering group, the main issues for London's rivers were described as '*fragmentation, improving hydromorphology, increasing floodplain connectivity and naturalizing banks'* (EA, unpublished, 2011). The challenges for river channel management described by Downs and Gregory (2004) provide a valuable set of indicators and key reference points for an evaluation of the planning and management of the MPRP case study and further arguments presented within this chapter. In Table 7.3 a third column has been added to the river channel management challenges identified in Chapter 2 (Table 2.9), to illustrate practical examples of the ecological objectives which project partners were working towards, as observed in the MPRP case study. These objectives carried a high profile within the MPRP case study, along with the social objectives of the wider project, partly because the restoration of the Mayes Brook was regarded as a demonstration site for river restoration under the London Rivers Action Plan.

7.2.2 Partnership characteristics and structures

The characteristics of partnerships described by Mackintosh (1992) and Bailey et al (1995) emphasise the dynamic and complex qualities of associations initiated by urban river restoration opportunities (Figure 7.1). When a restoration represents one part of an integrated river-park regeneration project, the multiple interests in the river and adjacent public open space are likely to be reflected by the diverse disciplinary backgrounds of partners contributing to the steering group decision making and delivery processes. This diversity of potentially competing interests therefore presents a risk that multi-disciplinary partnership may not achieve delivery of the most ecologically successful outcomes for urban rivers.

Table 7.3 Management challenges for river restoration and London rivers, relevant to urban river restoration and demonstrated by Mayes Brook case study. Adapted from Downs and Gregory (2004)

Main challenge	**Features included**	**Relevance to London Rivers(1) and Mayesbrook Park Restoration Project**
1. Manage rivers as ‘fluvial hydrosystems’, incorporating knowledge of past, present and future conditions ***(Spatial & temporal connectivity)***	Actions may be determined by habitat requirements of charismatic flora/fauna Identify best indicators of overall river ecosystem ‘health’.	*Catchment and landscape scale planning;* *Restoration of longitudinal and lateral connectivity[1];* *Coordinate replicable historic / baseline data;* *Integrate data management systems;* *Establish monitoring strategies;* *Maintain responsive / adaptive approach to future conditions e.g. changing climate, urban development.*
2. Integrate conservation actions with water resources and hazard management	One prospect is the role of restoring meanders and floodplains to act as flood retention.	*Natural flood storage objectives[1];* *BAP habitat creation (reedbeds, acid grassland);* *Misconnections project;* *Re-graded banks.*
3. Protect naturally functioning river systems *Adapted to:* ***Protect natural functions found within modified river system***	Preserve intact natural habitats.	*Protect existing natural features[1]:* *- aquatic and riparian habitats;* *- geomorphological diversity in un-restored reaches;* *- recorded aquatic and riparian dependent species e.g. fish, eel, kingfisher.*
4. Re-manage degraded systems	Improve environmental conditions and undo the degradation legacy through restoration.	*Reversal of historic management legacy through restoration and creation of new river channel[1].*
(1)LONDON RIVER ISSUES		
	Historic industry and flood management legacy; Regionally variable awareness of river eco-services value and opportunities to restore; Fragmented management across administrative boundaries.	*Restore longitudinal (fragmentation) and lateral connectivity;* *Hydromorphological diversity;* *Naturalise banks.*

Synergistic

Action orientated

Transformative
(developing new qualities or strengths)

Budget enlargement

Pragmatic

Responsive
to new opportunities

Minimal evaluation
of activities

Innovative

Maintain few records
of past achievements

Figure 7.1 Core processes and characteristics of partnerships depicted as a 'cloud'. (Adapted from Mackintosh, 1992 and Bailey et al. 1995)

7.2.3 The Mayesbrook (MPRP) partnership and network structures

As the MPRP partnership expanded to include additional organisations, informal networks and hierarchies were observed to develop between the core members and peripheral participants. These relationships developed according to roles, responsibilities and influence within the partnership; project stages and landmark activities e.g. events. Observations revealed a range of individual and institutional roles relating to: project management, specialist advice, sponsorship, facilitation and delivery.

Governance relationships, characterised by Lowndes et al. (1997) as partnerships and networks, describe the structure of partnerships as '*clearly bounded, stable and formalized by agreement*' suggesting a rigidity and inflexibility. The formal Memorandum of Understanding (MoU) produced by the EA in July 2009, identified the main MPRP partner organisations and provided a framework and identity to the project. However, the interactions and networks operating within the MoU partnership were observed to be fluid, focusing around individual roles and relationships, especially as external changes in political and wider economic circumstances led to reduced contact by some organisations.

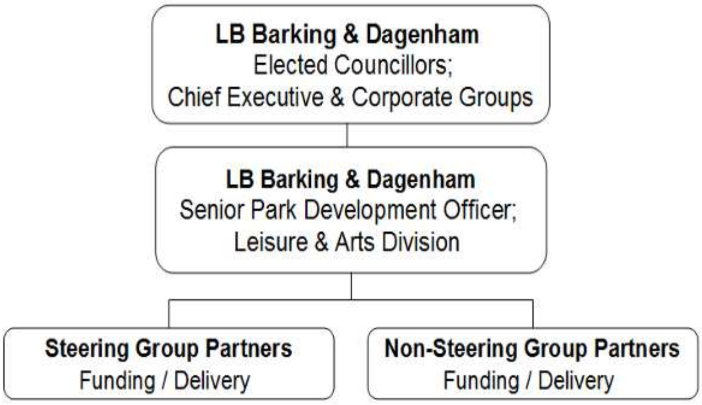
The flexibility of the partnership allowed for responsiveness and innovative solutions to be developed to changing circumstances as the project evolved. Beyond the MoU framework, the stability of the relationship between the lead partners (Local Authorities and EA) and the commissioned professional organisations (Landscape Architects, Environmental Engineers) also carried significant influence for the case study projects. The dependence of project partners upon the expertise of consultants to deliver key technical reports and the masterplan document escalated their influence upon project delivery, and had the potential to generate considerable risks where complications arose.

For the Mayes Brook and Ravensbourne (QUERCUS) case studies, the configurations of public sector institutional funding approval hierarchies (Figure 7.2), provide better examples of the rigid partnership model described by Lowndes et al. (1997). These structures, described as the ‘upper tier’ of the transnational partnership of the EU funded QUERCUS project (Woolley, 2009), were external to the project steering group but fundamental to the success of the project. They represent the bureaucratic ‘bigger picture’ consisting of senior managers and elected representatives to whom the lead project managers were required to report, in order to gain approvals for internal funding or major decisions.

At the QUERCUS ‘lower tier’ or local partnership level, for some key partners steering group membership also featured dual roles. In this case, the role of the EA alternated between advisor and regulator in response to project design developments to ensure the best environmental outcomes as they become more involved in the project (Woolley, 2009; Biodiversity Team Leader, EA, Interview comments, 2010). For the MPRP partnership, the connectivity and commitment of individuals and fluidity of networks extending beyond the formal MoU agreement allowed additional exchanges of knowledge to support decision making. For example, contributions during steering group meetings by visiting experts from the EA (engineering, hydromorphology, water quality), Thames Water (water quality) and Natural England (climate change adaptation, external funding) increased awareness of environmental and funding issues and options.

While the primary decision making responsibilities lay with the MoU signatory organisations, parallel roles for the formal and informal partnership networks were identified in relation to three aspects of the project process: (A) core decision making (by MoU commitment); (B) sponsorship (donor/ fund manager); and (C) practical delivery (e.g. of project reports or events delivery/ publicity/ media engagement) as shown in Table 7.4.

(a) MPRP case study



(b) QUERCUS case study

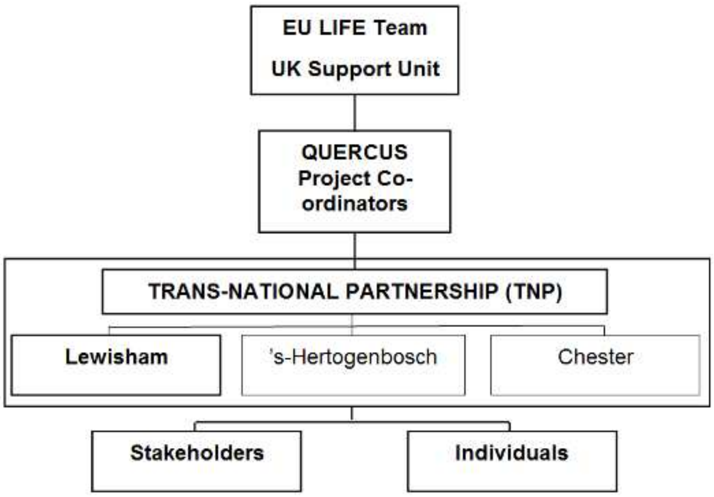


Figure 7.2 Project finance approval hierarchies within (a) LBBD and (b) QUERCUS project. (Adapted from Wooley, 2009)

When the observed partnership roles and sectors (or sources) are illustrated (Figure 7.3) the multiple roles of different sectors in relation to project processes are revealed. Leading partner roles taken by national level QUANGOs (EA and NE) and the Local Authorities are consolidated by decision making, resourcing and practical delivery. Important decision making and sponsorship roles are taken by Regional Authorities and regional QUANGOs. The Wildlife and River Trusts and local community groups were also observed to play important roles in decision making and practical delivery. No organisations were observed take a purely decision making role, emphasising the practical or funding investment contributions integral to the involvement of all sectors.

Table 7.4 Summary of main roles of core partnership and other actors within delivery network for MPRP.

Organisation (A-Z)	**Partnership (or Network) role for partners attending steering group meetings (Feb 2009 – Mar 2011)**		
	Decision making / MOU	**Sponsor-ship role**[1]	**Practical Delivery role** ***(i.e. additional or alternative to decision making / sponsorship role)***
EA – Environment Agency	✓	✓	Baseline survey reports; public consultation / meetings.
GLA – Greater London Authority	✓	✓	
Jacobs Ltd			Consultant engineers; scoping reports; detailed designs.
LBBD – London Borough of Barking and Dagenham	✓	✓	Project lead; project management; public consultation / meetings; publicity; liaison with LBBD senior mgmt, councillors, sponsors & delivery partners (Studio 3 Arts).
LDA [DfL] - London Development Agency [Design for London]	✓	✓	
LSx – London Sustainability Exchange			*(Seeking funding for community based project)*
LTWGS – London Tree & Woodland Grant Scheme		✓	
LWT – London Wildlife Trust	✓		Delivering schools environmental education project; weekly 'bush craft' activities; volunteer events.
NE – Natural England	✓	✓	Publicity and external bid writing support; liaison with delivery partners (LWT & Thames 21).
QD – Quartet Design			Landscape design; master planning; liaison with contractors.
QMUL – Queen Mary, University of London			Baseline survey reports (MSc – social survey/ sediment quality; PhD – Urban River Survey).
RRC – River Restoration Centre			Managing development of monitoring strategy; baseline survey reports;
RSA – Royal Sun Alliance		✓	Publicity; event management; volunteer events.
SITA Trust		✓	
Studio 3 Arts			Delivering schools art project.
TfL – Transport for London		✓	
Thames 21			Delivering volunteer events (Mayes brook clean up); schools environmental education project.
TRRT – Thames Rivers Restoration Trust	✓	✓	Publicity; finance management, public consultation / meetings, communication and liaison with sponsors and stakeholders.
TW – Thames Water			Misconnections project in Mayes brook catchment.

[1] Source: Cost Plans, April 2010-May 2011

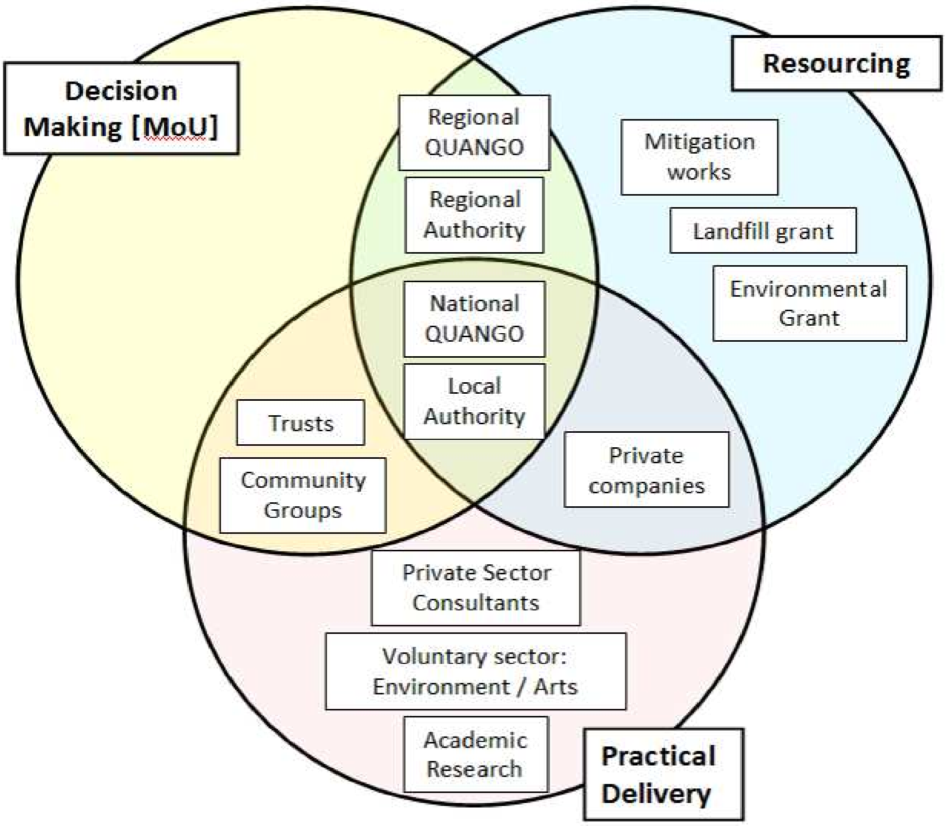


Figure 7.3 Summary diagram illustrating observed partnership roles for key organisations and sectors in relation to urban river restoration planning in London.

7.3 Partnership life-cycle stages and timing

Integrated urban river restoration projects each encompass unique combinations of environmental and social variables which can influence individual projects and partnerships in different ways. To gain understanding of the restoration partnership processes, the generic partnership life-cycle stages described by Lowndes and Skelcher (1998, introduced in section 2.3.2) provide a useful starting point for interpretation of the MPRP partnership observations (Table 7.5). The third column of Table 7.5 indicates the governance characteristics identified through observations of the MPRP partnership at each life cycle stage.

The process of breaking down observations into life cycle stage components provided insights into development of the partnership and facilitated interpretation of the internal mechanisms and emerging issues. The life cycle framework provided a theoretical structure for investigations into the MPRP project timeline described in the next section.

Table 7.5 Partnership Life-cycle stages and summary of characteristics identified through case study observations. Adapted from Lowndes and Skelcher, 1998.

Life cycle stage	Mode of Governance	Observed governance characteristics
Pre-partnership collaborations	Networking: individuals/ organisations	- Parallel early collaborations: independent starting points focused around river-floodplain-park / restoration-regeneration plans and visions.
Partnership Creation and Consolidation	Hierarchies established; Formalisation of authority	- Project unified and defined as integrated river-floodplain-park restoration vision; - Project lead established (Local Authority); - Partner commitment formalized through 'Memorandum of Understanding'; - Hierarchies established through roles: e.g. statutory, sponsorship, expertise etc; - Project publicized: through funding competition, public consultation and VIP events; - Partner-project attachments and investments create some dynamics through 'ownership' issues.
Partnership Programme Delivery	Market mechanisms: contracts; Regulating: contractors; Networking: bids	- Strategy development for funding and risk management (project delivery focus); - Differentiation between funding and delivery partners; - Legacy planning (Monitoring strategy / Park Ranger post funding); - External influences on project, partnership roles and structure (spatial / political) - Contractor / bureaucratic delays; - Monitoring strategy and project appraisal planning; - Project Delivery: capital works/ contract management; (END OF RESEARCH PERIOD)
Partnership Termination and Succession	Networking: individuals / organisations	- Ongoing engagement enabled through dedicated post (Park Ranger, 3 yrs); - Phase II planning;

7.3.1 The Mayesbrook (MPRP) partnership life cycle

The life-cycle stages outlined by Lowndes and Skelcher (1998) representing 'internal' time factors, aided interpretation of the MPRP time line (Table 7.6) and the evolution of project planning and management processes. Together with Mackintosh and Bailey's partnership characteristics (Figure 7.1), these are used to investigate the structural variations in governance and dynamics observed within the MPRP steering group through each partnership stage.

i. Pre-project collaborations

As the project timeline in Table 7.6 indicates, the history of the MPRP project began with multiple pre-partnership collaborations as informal and fairly fluid associations involving the Local Authority (LBBD), QUANGOs (EA and NE) and environmental trusts (TRRT and LWT). These early networks involved preliminary scoping

Table 7.6 MPRP time line interpreted through Partnership Life-cycle stages
Sources: LBBD MPRP steering group minutes and interview data

STAGE	YEAR	PROJECT LANDMARKS
Pre-partnership collaborations	2003	LBBD Parks and Green Spaces Strategy identifies need for Mayesbrook Park restoration
	Pre-2007 Scoping activity	LBBD: Parks and Green Spaces Strategy regeneration sites EA/LWT/NE/WWF: LRAP river restoration demonstration sites (RRC, 2007) TRRT/GLA /NE/LWT: Wetland Vision: urban wetland / river restoration sites RSA/WWF/TRRT: Natural flood storage demonstration sites
	2007	07/07 LBBD produce Draft Mayesbrook Park Masterplan brief 08/07 LBBD/EA/DfL partnership forms; EA commission full feasibility study for integrated river-park regeneration project (by Jacobs); LBBD, DfL, EA fund scoping & feasibility reports
Partnership creation and consolidation	2008	07/08 LBBD/EA /DfL and TRRT/GLA/NE/LWT groups merge to create MPRP steering group; lead partner: LBBD 09/08 Partnership consolidated through Memorandum of Understanding 10/08 MPRP options workshop 12/08 LBBD commission Masterplan and Connectivity reports (by Quartet); GLA Priority Parks competition entry; Public promotion of competition in park and neighbourhood Partnership invite additional members: Thames Water & Forestry Commission
Partnership Programme Delivery	2009	01/09 LBBD consultation with ward councillors 02/09 LBBD apply to Access to Nature fund (focus Friends Group / Conservation volunteers) NE Natural Connections (I) funds schools engagement projects, delivered by LWT and Studio 3 Arts 03/09 GLA funding secured 07/09 Community consultation event in park; Park user baseline report (MSc study) 09/09 RSA volunteers event programme begins 11/09 RSA funding secured; Trees for Cities - community planting event;? Adizone fund outdoor gym Funded by Department of Children Schools Families and Barking and Dagenham Primary Care Trust

	2010	01/10 Technical design meeting; Monitoring strategy workshop (I) 03/02 NE Natural Connections (II) funds further schools projects, delivered by LWT, Thames 21 and Studio 3 Arts 04/10 TW Misconnections project updates; Phase 3 Detailed Design report delivered 05/10 Funding Workshop 07/10 MPRP Official (VIP) Launch Event 08/10 Planning Consent Application; EA Biodiversity Phase 1 Report 09/10 Public planning consultation event; LBBD liaise with Olympics project in park; Access to Nature funding secured (3 yr Ranger Post); Risk Workshop 10/10 LBBD/EA update residents group meeting 11/10 Masterplan sign off; SITA funding secured 12/10 Planning approval gained; NE Natural Connections funds engagement projects (LWT deliver)
	2011	01/11 Monitoring strategy workshop (II) 02/11 Contractor for works awarded Tender; EA additional funding secured 03/11 MPRP Official (VIP) Start on Site event Work begins on site; RRC develop Information Base and Monitoring strategy using PRAGMO 04/11 Access to Nature engagement project commences 06/11 Ongoing consultation with residents to resolve site based issues and concerns over security. 07/11 Project expanded to include Olympic SUDS scheme (ODA funded) 12/11 River restoration works due for completion on site.

investigations for opportunities to demonstrate new strategies and plans including the LBBD Parks and Green Spaces Strategy (PGSS), London Rivers Action Plan (LRAP, EA), Wetland Vision (NE) and East London Green Grid (LDA/DfL).

The starting points for these collaborations were staggered according to the individual pre-partnership histories, emerging at different spatial scales with a regional or borough focus. The early stages were primarily driven by the core environmental or socially-oriented objectives of the organisations involved, with scoping studies facilitated by minor or ‘seed corn’ funding opportunities (via EA and DfL). (The integration of objectives and resourcing are explored in more detail in sections 7.4 and 7.5, respectively). Meanwhile, as part of the national ‘Connect Right’ campaign (initiated in 2009), the Thames Water Environmental Protection Team were also actively addressing water quality issues in the Mayes Brook catchment by tracing sources of pollution to misconnected properties.

The potential to create a more substantial integrated project was realised as the separate collaborations became mutually aware and generated the momentum to connect and extend individual project proposals. As such, the synchronicity between each initiative and the geographical foci of Mayes Brook and Mayesbrook Park formed the basis for the identification of common ground, which enabled progression to the next stage of partnership.

ii. Partnership Creation and Consolidation

The MPRP partnership was consolidated under the leadership of the Local Authority (LBBD) in July 2008 with the EA as lead technical partner for the river works. The identity and commitment of the main partners was formalised through a non-legal ‘Memorandum of Understanding’ (MoU) document, drawn up by the Environment Agency, which detailed terms and conditions relating to confidentiality, intellectual property, resourcing and finances, tendering, invoicing, publicity and termination. The MoU committed signatories to delivering the project according to strict environmental criteria (e.g. energy usage and waste etc), thereby acknowledging national commitments to sustainable development (EA, unpublished, 2009). The private sector organisations were not signatories of the MoU although they played a number of key roles throughout the project life-cycle as sponsors, via independent contributions to environmental objectives (e.g. Thames Water’s misconnections project) and consultants.

The local authority, LBBD were nominated as lead project manager in recognition of their position as landowner and responsibility to represent the joint interests of the natural environment (of Mayes Brook and Mayesbrook Park) plus local communities and park users. The case for a full time project manager post, funded by the project, was raised early on in recognition of the expected workload. In contrast to other urban river restoration projects (i.e. the case studies and other GLA Priority Parks projects), a dedicated project management post was not funded, so this role was performed throughout by a Senior Parks Development Officer alongside other duties.

As the partnership developed, hierarchies associated with decision making, resourcing, and delivery were defined by technical expertise in relation to: the river, landscape design and stakeholder engagement. The dynamics generated via the internal networks and expertise differentials were observed in relation to the dominance of agendas or discussion time by different thematic ’voices’, which carried different emphases at various project stages. A review of these dynamics in terms of objective integration is developed in section 7.4.3.

Further networks associated with consultation or landmark events involving planning, delivery and publicity activities also required the coordination of external engagement or activities with local community or VIPs (e.g. at launch events). In these cases dynamics relating to partner organisation profiles and operational approaches generated some minor tensions, which are reviewed in terms of decision making in section 7.4.4.

iii. Partnership programme delivery

The main practical activities involved in planning and delivering an urban river restoration project, were identified through the case studies as:

- decision making and consensus building (master planning)
- public engagement and consultation
- fundraising and resourcing
- approval or consenting
- publicity and events
- information management

Management of the MPRP case study was facilitated using PRINCE2 (PRojects IN Controlled Environments 2) software, a standard model endorsed by local government, which includes the use of GANTT charts as a flexible time management tool. These charts enabled partners to observe variations between project components running in parallel and the evolution of different priorities at various planning stages. The flow chart in Figure 7.4 illustrates the MPRP project stages and parallel programmes for environmental assessment and consultation that were integrated through the masterplan. The plural delivery streams show the time bound capital works running alongside the longer term (engagement and monitoring) project legacy planning stages.

During programme delivery, in parallel with the progression of project design and acquiring the necessary permissions, the development of funding and risk management strategies also became necessary, demanding additional attention and time allocation. These two elements were present but unconsolidated during early project stages, therefore a more focused planning approach to ensure adequate resources and successful delivery, including extra meetings with external advisors, became a priority during 2010.

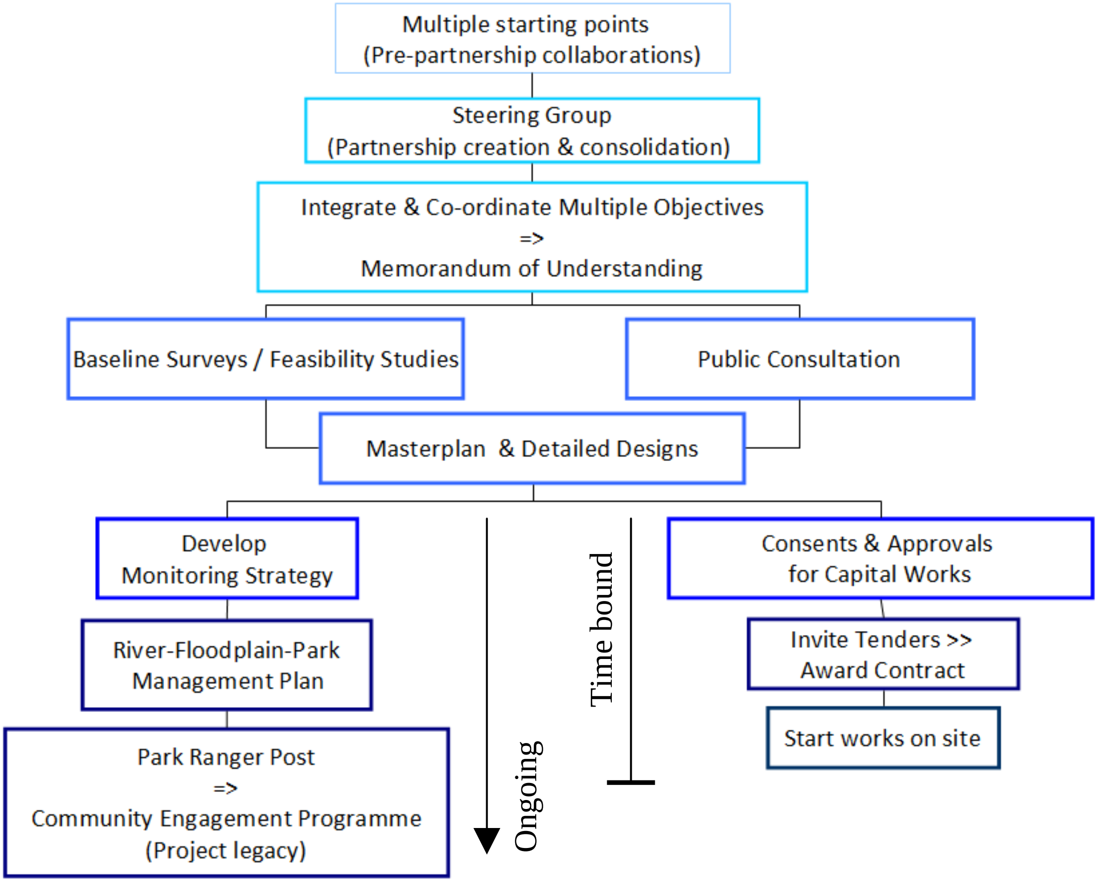


Figure 7.4 Flow chart of project stages shown as a process (cascade) diagram.

Regular inclusive steering group meetings, held throughout the programme delivery stage, often involved lengthy decision making discussions lasting up to four hours. Intervals between meetings were between six weeks and three months depending on the project stage, with special focus meetings (generally involving the whole steering group plus additional advisors) held in between (Figure 7.5). Steering group attendance numbered between four and thirteen depending upon the agenda items and additional advisors present, peaking in late 2010/early 2011 and coinciding with the preparation of the tender and planning consent application (Figure 7.6).

Other external issues arising during programme delivery included the need for spatial coordination with other projects on site (e.g. Olympic sports development); political change (e.g. organisational cutbacks); and delays (e.g. bureaucratic frameworks). Each additional factor added layers of complexity to partnership planning and management processes. In most cases the main responsibility for these fell to the lead project manager, placing considerable pressure on that role (especially alongside other duties). The importance of good support networks providing administrative and technical expertise to project lead partners was emphasised by the observed demands of coordinating a wide range of different bureaucratic and technical challenges throughout this project stage. The challenges of integrating technical expertise within multi-disciplinary partnerships to support urban river restoration decision making are discussed in section 7.4.3. The research period and observations ceased towards the end of this stage, as earthworks began on site in Spring 2011.

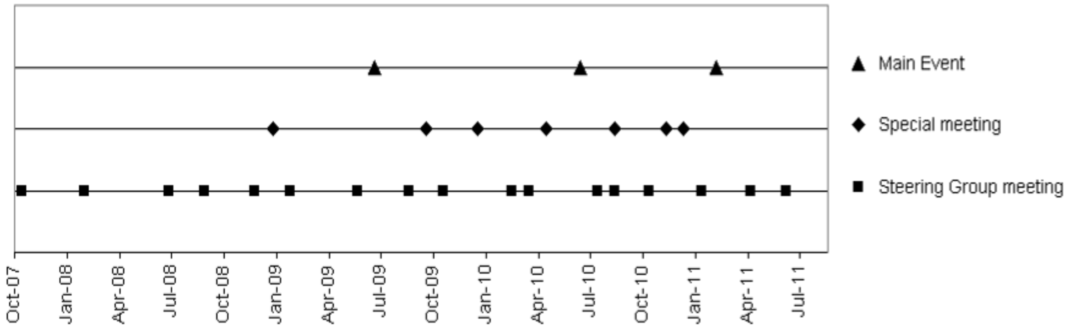


Figure 7.5 Event timeline indicating frequency of steering group and special meetings, plus main public and VIP events for MPRP case study.

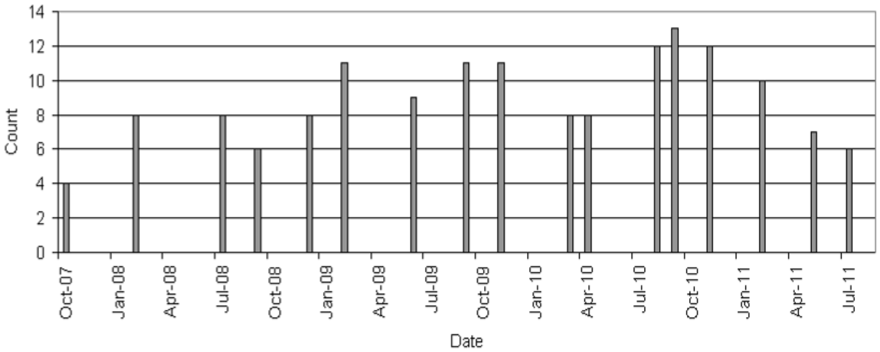


Figure 7.6 Timeline indicating frequency of steering group meetings and counts of attendees at each meeting.

iv. Partnership termination and succession

Due to planning delays during programme delivery, the research period did not extend into the partnership termination stages, therefore only the preparations for partnership succession and post project appraisal legacy were observed. However, observations and involvement during the development of an integrated multiple-objective monitoring strategy contributed significantly to this thesis (reported in section 7.4.4). In contrast to the common failure of partnerships to record achievements and evaluate outcomes (noted by Bailey et al. 1995), examples of positive post project monitoring legacy are provided by both MPRP and QUERCUS case studies.

For the QUERCUS project, the development of stronger links between the EA and LB Lewisham planning department resulted in the establishment of an improved internal planning consultation strategy, including regular planning 'surgeries' with EA officers visiting LB Lewisham planning teams to assist with planning queries (DCLG, 2009). Within the Ravensbourne catchment ongoing monitoring by LB Lewisham parks Rivers and People Officer and local stakeholder engagement continues to provide evidence for the social benefits of urban river restoration. The environmental outcomes (reported in Chapter 4) provide evidence for early habitat quality improvements, and a successful £2m bid to fund restoration of adjacent reaches upstream led to the completion of additional socio-ecological enhancements to the Ravensbourne in 2011 (Figure 7.7).

Figure 7.7 View of a section of the follow up restoration on the river Ravensbourne (Parklands project) in 2011 after success of the QUERCUS project completed in 2008.

7.3.2 External time factors affecting urban river restoration planning

Analysis of the interview data highlighted further issues relating to the additional time requirements for urban river restoration planning and management. These issues were found to be closely linked to the challenges for interdisciplinary approaches identified in Chapter 1. Beyond the internal partnership life-cycle stages, the need to coordinate with external time factors presents considerable challenges to multi-disciplinary restoration partnerships and the timely delivery of ecologically successful outcomes. Effective time management is fundamental to the planning and delivery of any programme of works. For an urban river restoration, the combination of different environmental and social time scales and contrasting perceptions of time brings particular challenges to multi-disciplinary partnership work and restoration project management.

Interview data revealed several issues and some concerns surrounding time. In the context of the two overarching themes of partnership and urban river restoration management challenges, the next section investigates the emerging issues surrounding the sub-themes of:

- Contextual time – policy and political paradigms,
- Institutional time - bureaucratic time
- Environmental time – assessing and monitoring; surveys and permissions
- Human time – stakeholder engagement and individual circumstances

This section highlights issues raised during interviews and compares these to MPRP steering group meeting observations and secondary data relating to the Ravensbourne (QUERCUS) and Brent (BRPRP) case studies where applicable.

i. Contextual time

The new policy approaches described in Chapter 5 offer unprecedented support for the sustainable development of aquatic and urban environments. While these are generally non-mandatory, they provide strong justifications for undertaking integrated urban river restorations for the benefit of people and wildlife. Backed up by timely political rhetoric in support of sustainable environmental practice, engagement strategies encouraging participation in environmental projects are targeted at multi-disciplinary organisations across all sectors (Entec, 2008). The introduction of such high level policies is providing important legitimacy, and as the LRAP data analyses (section 6.3) suggest, encouraging sponsorship and delivery of an increased number of restoration projects by a wide range of partners within London. For example, the MPRP case study represents a project specifically intended to demonstrate policy aims for urban river restoration, natural flood management, parks development, urban greening and climate change adaptation both in London and nationally.

> *'..what they* (the EA) *were looking for was firstly, to have a London rivers action plan: which was completed January of this year (2009); and the other thing that they were looking for was to have a demo site like a flagship river restoration site in London.'* (Conservation Technical Specialist, EA, Interview comments, 2009)

By contrast, other case studies originated primarily from localised responses to flood management works (BRPRP) and community demand (QUERCUS), which synchronised with funding opportunities associated with local regeneration (BRPRP) or planning agreement (via Section 106, QUERCUS). In all of these cases, the motivation of key individuals in driving projects forward coinciding with supportive policies plus essential funding opportunities demonstrates the importance of these contextual factors for the successful timing of restoration projects. (Further exploration of timing issues relating to project funding is covered in section 7.5).

ii. Bureaucratic time

Interview and observation data provide evidence for discontinuities occurring between predicted time frames and real time progress within the MPRP and QUERCUS project programmes. In each case the time requirements of different project components (e.g. planning application preparations, ‘upper tier’ approvals) or unforeseen delays impacted upon delivery schedules. In particular, the involvement of public sector Local Authorities presented additional administrative demands associated with the unfamiliarity of river restoration works and approvals.

> *‘..this project is first I’ve worked on where the lead organisation has been the Local Authority, and that has helped the project in many ways, but it has also thrown up the fact that Local Authorities are generally not geared up to do this kind of project. We have had to struggle a bit to get this project through some of the councils processes and systems, both approval systems, financial systems ,….*
>
> *.. Local Authorities need to develop and improve certain parts of their systems and may need to be given some more powers and flexibility if they’re going to lead on these projects in future..’*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

Bureaucratic time scale differences between institutions, associated with the pace, structures and procedures within different work cultures resulted in temporal discontinuities for each case study. In particular, interview data highlighted issues associated with work culture differences between the public and private sector organisations (MPRP); and within different bodies, levels or departments of public sector organisations (QUERCUS) e.g. within the same local authority or between British and European levels. In both cases, partner expectations of how systems functioned contrasted strongly with the reality, resulting in some tensions and requiring further time to develop mutual understandings and progress. The pace of work differential was clearly illustrated by the comments of the private sector partner after delays pushed their expected project start date back by 12 months.

> *'..In RSA you know the way I work I can turn stuff around quite quickly but I think when you look at the council it's slightly different. They have to wait for a certain board meeting or whatever it is and then go through a certain process.'*
>
> *'Some of it might be out of our hands, basically it's out of our control, so all I can do essentially is put the pressure and make sure we do meet this deadline and we do deliver the project according to the time line.'*
>
> (CSR Programme Manager, RSA, Interview comments, 2010)

In both case studies, bureaucratic differences between the funding and delivery partners led to contrasting expectations regarding processing times, which were managed by the lead managers in different ways.

For MPRP, delays and tensions associated with the required public authority approvals and sign-offs were effectively diffused and different expectations bridged through increased flexibility, a facilitating partner and regular communications by phone and email between the organisations involved. This proactive communicative approach successfully reduced the impact upon steering group time or processes.

> *'..sometimes sitting around a table you can see that the timetable doesn't always mesh with the timetable of the other partners so there's a certain amount of talking to people and trying to keep them happy behind the scenes'*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

For the QUERCUS project, delays in discovering discontinuities between the accounting approaches of the Local Authority and EU Life fund managers also led to tensions and further delays requiring detailed personal communications and liaison to address the problematic issues.

> *'.. half way through the project, …..and only by letter did we have any idea that anything was wrong, by which time we'd employed X* (Project Manager), *we'd employed the Waterway Rangers who had started, the consultants and were getting around to getting the contractors to deliver – and it was 'Why at this point are you telling us?'* (European Projects Manager, LBL, Interview comments, 2010)

The internal bureaucracies of the local authorities also impacted on project progress, in areas such as planning (as an in-house, but 'bought-in' service), tendering and contractor procurement.

> *'… there's block review in Lewisham, tendering stuff takes a long time you know, I had to wait for approvals to award the contract .'*
>
> (QUERCUS Project Manager, LBL. Interview comments, 2010)

Procurement constraints affecting the transfer of an environmental consultancy contract from the EA to the local authority became problematic for the MPRP. Without an existing suppliers or framework agreement, additional internal approvals were required leading to significant delays and loss of continuity between the partners, resulting in the delayed delivery of final channel designs.

Case study observations indicated the close associations between the timing of key planning decisions, actions and events and project schedule. Time management strategies involving the maintenance of 'live' GANTT charts, document logs and timetables for reports, meetings, events and surveys, all facilitated communications within the partnership. These records were particularly effective in managing changes associated with staff turnover, where knowledge exchange helped to get people 'up to speed' with the project. During the observation period, information management was undertaken by the lead project manager, and summaries circulated according to need. As observation ceased, a new internet-based 'remote' information store, accessible to partners by password, was launched as a trial for ongoing partnership stages including MPRP Phase 2 planning.

iii. Environmental time

Issues arising from the influence of environmental time scales upon urban river restoration relate to the regular seasonal cycles (affecting survey timing, work restrictions); irregular or stochastic events (flooding or drought); plus environmental responses to impacts over long and short timeframes e.g. channel responses to restoration works. As well as the potential for unexpected (local or remote) responses to restoration works, emerging issues surrounding environmental time related mainly to activities involving ecological surveys, work on site and people engagement (Table 7.7)

Table 7.7 Summary of issues relating to urban river restoration project activities.

Activity	**Environmental time issues**
Ecological surveys	- baseline data (assessment options, organism life cycles); - monitoring (post project appraisal schedules, adaptive management strategies)
Work on site	- Biodiversity protection activities (pre-/during works) - Planning permissions (conditions for work schedules)
People engagement activities:	- e.g. planting, installing bird boxes etc

In order to meet future urban river management challenges relating to functioning and responses to restoration works, pre-works baseline data are essential at affected reaches and where feasible at either catchment scale or, as a minimum, at adjacent reaches. The availability of MPRP baseline data during early design stages were essential for the landscape design and river engineering consultants responsible for the masterplan and detailed designs to take account of current bio-physical conditions.

> *'..the background information was available, although there were elements that were absent as I said, like a topographical survey, like a detailed tree survey, you know which would start to be key when you start to come down to the detailed level that the project needs..'*
> (Senior Landscape Consultant, Quartet Design, Interview comments, 2010)

Project schedules were therefore influenced by the timing of ecological data surveys: where these were determined by seasonality or life cycle; and physical river surveys designed to coincide with 'dry weather flow' conditions; and the availability of suitably specialist surveyors within specific timeframes.

Awareness of and coordination with ongoing flood risk management operations was also highlighted during environmental surveys undertaken by the author when 'channel cleaning' (i.e. cutting vegetation back to its base) between surveys on adjacent reaches (a) had a significant impact on the appearance of channel features (mitigated by earlier view of uncut channel), however (b) also provided valuable information about channel management and features that were previously obscured by dense vegetation (Figure 7.8).

Figure 7.8 Indicative views of MPRP reaches (a) before and (b) after vegetation cutting

To support future river management strategies, gathering replicable baseline data is of prime importance to the establishment of viable monitoring programmes, demonstrating responses and attracting support for future projects. The use of standardised bio-physical assessment methodologies facilitates response interpretation and provides consistency over time when undertaken by different surveyors. These factors were especially significant for the MPRP partners, seeking to gather evidence to demonstrate urban river restoration outcomes in relation to specific objectives such as climate change adaptation.

> *'…on the work that we're doing, I want to be able to show the baseline and the monitoring. So from an adaptation point of view monitoring is very important, because climate change is not clear cut.*
>
> *... We're working with a range of potentials and we don't really know what's going to happen, adaptation is a very dynamic process. When you intervene you have to monitor whether that's actually working, so you can then adjust your approach - it's adaptive management.'*
>
> (Climate Change Adaptation Advisor, NE, Interview comments, 2010)

The effective scheduling of works on site was a priority for the MPRP project manager, firstly to comply with strict environmental planning conditions, and to minimise impacts on project finances. Prior to major earthworks commencing, site preparations or 'enabling works' were undertaken at a seasonally appropriate time to minimize the impacts upon wildlife by removing habitat ahead of the main operations.

> *'..the programme that we've been following: getting the major elements underway late March into April, is going to be the most efficient time because the contractor's going to be risk averse, so therefore he's going to price it accordingly…*
>
> *..as long as you've got the ecological constraints dealt with in terms of tree removal and habitat removal.. it's got a lot to it but it's only six months work..'*
>
> (Senior Landscape Consultant, Quartet Design, Interview comments, 2010)

As MPRP enabling works gave a visual cue to local people of work commencing in the park, information boards were also used to inform the public of their positive and protective effects and public communications were included in contractors' agreements. Contrary to local authority fears, the risk of a negative public reaction to tree removals did not materialise, suggesting that the public were adequately informed about the nature of works. Other preparatory community and volunteer tree planting events within the park also demonstrated a commitment to ensuring a net gain in tree cover to offset the floodplain losses.

The inclusion of BAP habitat targets creation focused considerable attention upon the protection of existing habitat for specific species e.g. bats and birds. The timing of species surveys, determined by seasonality and life cycles, demanded consideration in relation to the delivery programme and became a critical factor where gaps were highlighted within the planning order (LBBD, 2011).

> *'13. The development shall not be commenced until a reptile survey and implications assessment of the site by a qualified ecologist has been submitted to and approved by the local planning authority. The survey shall be carried out between the months of*

> *April and October. Any agreed habitat mitigation measures shall be carried out in accordance with the approved details'.*
> (Planning Order, Regeneration & Economic Development, LB Lewisham, Feb 2011)

The importance of coordinating the delivery of people engagement activities involving environmental arts and education activities (e.g. tree planting, river dipping) around seasonal opportunities was also emphasised during MPRP steering group meetings. Further examples of the importance of 'human time' in relation to people engagement are discussed below.

iv. Human time

Interview and observations data indicated the timing of stakeholder engagement as a key element of urban river restoration planning. Firstly, stakeholder involvement at the pre-partnership collaborative stage was identified as a vital factor. For example, long before the QUERCUS project began, discussions between the local community and the EA regarding river restoration options at Ladywell Fields were initiated by residents, following experience of earlier works within the catchment.

> *'..So going back a long way, .. we were approached by friends of Ladywell Fields which is the Park User Group- ..*
>
> *..I don't know why they contacted us, but I think it was probably because we had been involved quite a lot in Lewisham with works on Chinbrook Meadow and Sutcliffe Park and such like, and so I think that they already had an aspiration that they could improve their park by involving the Agency in doing some river improvement work.'*
> (Biodiversity Team Leader, EA, Interview comments, 2010)

For other projects, community demand may not provide an early catalyst. For the MPRP, engagement activities carried out under the Natural Connections programme from partnership consolidation stages, continued to run in parallel to the urban river restoration capital works programme throughout the delivery period. The low profile of some engagement activities reduced the visibility of this synchronicity for some partners. However, this connectivity became more apparent and integrated as planning progressed, particularly through the development of the multi-objective monitoring strategy and in terms of the future engagement legacy involving a 3-year Park Ranger post financed through Access to Nature funding.

Following restoration works, the value of post-project stakeholder engagement is also demonstrated by ongoing stewardship activities taking place in catchments such as the Ravensbourne/Quaggy and Wandle. Here local people continue to contribute their time and energy to maintaining river habitat quality through the removal of rubbish and invasive plants long after restoration partnerships are terminated.

The case study examples indicate different approaches and starting points within the community reflecting different levels of interest, awareness and human connectivity with local urban rivers. Likewise, differences in levels of engagement in ongoing stewardship activities between catchments reflect not only the successful establishment of ‘Friends’ groups (e.g. in Brent River Park) or river focused organisations (e.g. the Wandle Trust), but also the enthusiasm of key individuals or ‘champions’ able to donate time to sustaining such groups as well as different social demographics.

7.3.3 Conclusions of partnership investigation

This section has provided a broad overview of the characteristics and structures of multi-disciplinary partnerships, and time factors involved in urban river restoration. Analysis of the MPRP observations finds that the internal structures and dynamics of the MPRP partnership operated as a complex hybrid arrangement of formal and informal relationships and networks initially driven by organisational motivations in the early inception stages and evolving through the partnership consolidation and delivery stages. The roles and relationships which emerged through these stages remain strongly associated with original motivations and expertise, becoming synchronised within the partnership as connectivity and common purpose were identified and developed into increasingly interdisciplinary perspectives. For example, issues relating to the management of water quality and the focus on climate change adaptation each crossed the environmental:social disciplinary boundaries providing unifying overarching themes. The integration of motivations and objectives is investigated in further detail in Chapter 8.

The transition towards integrated project-focused objectives reflects the current policy drivers (reviewed in Chapter 5) and the influence of sustainable development principles and ecosystem approach policies which require partners to be flexible, synergistic and transformative (Figure 7.1) by encompassing interdisciplinary perspectives alongside their specialist knowledge. The ethnographic data provide substantial evidence for these partnership qualities within the MPRP partnership throughout the life-cycle stages, as further detail within the following sections and Chapter 8 will confirm. The emphasis on sustainable development is also driving legacy planning, as demonstrated by the

QUERCUS and MPRP case studies, thus countering the negative partnership characteristics of minimal evaluation and recording identified by Bailey et al (1995) and Mackintosh (1992).

In the following section, further evidence of partnership processes and time issues are investigated in relation to the challenges and strategies for resourcing urban river restoration projects.

7.4 Resourcing urban river restoration: Funding structures and processes

Building upon the analysis of the RRC/LRAP data, this section provides insights regarding the variety of urban river restoration resourcing opportunities, and challenges relating to integrating multiple funding sources, identified through the MPRP and QUERCUS case studies.

The EA have a long history of river restoration involvement in the Thames region, with money ‘set aside’ for restoration work through flood defence budgets (Bruce-Burgess, 2004 p.141). The NE Thames area annual budget (approximately £150,000 pa), is managed by the Flood Risk Management (FRM) Team specifically to rehabilitate rivers negatively impacted by FRM practices across the region (Conservation Team Leader, EA, Interview, 2010). However, this sum appears modest when compared to annual average spending on London river restorations since 2000 at >£1m (section 6.3.4).

As the LRAP data demonstrate, financing restoration projects may involve up to five sponsors from charity, public or private sectors, at regional, national or EU levels (section 6.3.3) resulting in diverse combinations and challenges. For the QUERCUS case study, having one major funder (plus minor matched funding) involved complex administration demands which took additional time and attention to resolve. Nevertheless, the process and highly positive outcome of the project forged strong relationships between the local authority and EU Life Fund Managers on completion.

> ‘ *there were times when I could have quite easily jacked it in – it was getting a letter from the EU which was so, you know, faceless and critical of everything that you’ve been doing, but again once you get past that …*
>
> *.. it did change, and having him come along with the Head of the Fund to that event at the end that was a real, it just was a real pat on the back for us, all we’d been involved in, because it was obvious that that didn’t happen to everybody..’*
>
> (European Projects Manager, LBL, Interview comments, 2010)

Whereas a few projects have a mega-fund to finance capital works (typically requiring a degree of ‘matched’ funding), in other cases, a combination of different funding sources may be needed to meet the expectations and objectives determined through the partnership. In many cases, ‘matched’ funding may be drawn from ‘in kind’ resources representing working hours of practitioners or volunteers. These highly valued and significant contributions are typically monetised at an hourly rate and may be derived from the private, public and voluntary sectors or local communities.

The MPRP provides an example of a patchwork of ten independent funding sources secured during 2009-10 to meet the environmental and social objectives for Phase 1 (Table 7.8). These multiple sponsorships came together in stages to meet partners’ criteria as different funding challenges and opportunities were identified. The realisation of a potential funding shortfall in early 2010 (due to delays in the potential availability of approximately £1m from an adjacent residential development planning agreement) coupled with restrictive funding conditions, resulted in uncertainties over whether Phase 1 core objectives would be met. While the active engagement and flexibility of regional sponsor (GLA) allowed some negotiation over funding agreements, the organisation of a special meeting in May 2010 focused the partners’ efforts towards a programme of grant applications, which succeeded in meeting shortfalls just ahead of tendering in November 2010.

Within the final package, a review of the funding agreement conditions revealed four out of ten sources to have integrated socio-environmental objectives, while the remainder were broadly divided between river-floodplain and park-people themes, as indicated in Table 7.8.

7.4.1 Funding timetables

Further to the discussion of time factors in sections 7.3.1 and 7.3.2, comparison between the MPRP and QUERCUS case studies revealed that issues of time and time planning placed unforeseen demands on both partnerships. The evidence of these studies indicates that the sourcing and management of funding requires considerable investments of time, energy and expertise. However, this may vary according to funding source. For example, the Parklands project (follow up to QUERCUS) also succeeded in winning mega-funding from a regional source (LDA) but involved considerably less administrative efforts compared to the EU Life funding (Project Manager, LBL, Interview comments, 2010).

The wide range of sources for urban river restoration projects indicated by the LRAP/RRC data (section 6.3) signals the diversity of funding partners, grants and finance opportunities (Figure 6.7). Each external funding application demands a considerable investment of time, especially when overall funding strategies need to be carefully tailored to fit potential but typically conditional sources to multiple socio-environmental objectives (or vice versa). In recognition of the complexity of grant funding processes, a new external funding advisory service for the London region was established by Natural England in 2010, to help project managers identify suitable funding sources, plan funding packages and navigate the applications process. This service appeared at a crucial time for the Mayesbrook project.

> *'…. when I was doing that workshop earlier this year, we were talking about being on site in January – and I was like, '.., there aren't many deadlines you know', funders have up to four deadlines a year, that can take again a couple of months for assessment of decisions.'*
>
> (External Funding Delivery Leader, NE, Interview, 2010)

Without the extra funding needed to deliver all the desired reaches for Phase I, a real risk of falling short of expected delivery objectives was a concern to several partners. The funding timeline shown in Figure 7.9 gives a general representation of the three 'rounds' of funding that were incoming to the MPRP.

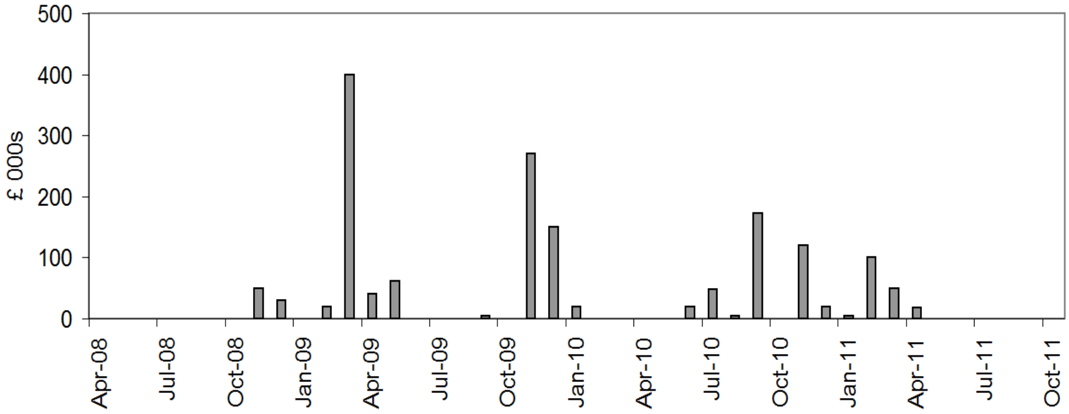


Figure 7.9 Time line indicating the main funding landmarks and three (annual) 'rounds' of funding that supported the MPRP. (Based upon approximate timings indicated in steering group minutes and cost plans).

Table 7.8 Overview of funding sources: their main objectives and priority focal points

			Priority focus			
Source / Fund manager	**Fund Description**	**Objectives / Outputs / Conditions**	**River**	**Floodplain**	**Park**	**People**
CAPITAL						
EA	Flood management / Restoration funds / BAP habitat creation	River restoration; LRAP demonstration; natural flood storage; BAP habitat	✓	✓		✓
GLA	Priority Parks fund	Transformation of park; river and park environments; furniture & entrances	✓		✓	✓
LBBD	Local Authority Parks and Green Space Strategy capital funds;	Park regeneration; increase visitor numbers; BAP habitat.			✓	✓
LTWGS	London Tree and Woodland Grant Scheme	Trees and woodland planting & conservation			✓	
NE	Contributing Third Party (CTP) funding	11.5% contribution required to release SITA grant	✓			
RSA	Royal Sun Alliance environmental fund	River restoration & natural flood storage demonstration	✓	✓		✓
SITA Trust	Landfill environmental funds	Natural environment; conservation	✓			
TfL	Transport for London mitigation funding	Environmental mitigation works and access improvements			✓	✓
REVENUE						
EA	Revenue funding (for consultancy)	Scoping and Feasibility reports	✓	✓		✓
DfL	East London Green Grid / Urban design funding	Connectivity study			✓	✓
LBBD	Revenue funding (for consultancy)	Consultants for landscape design and river engineering			✓	✓
NE	Natural Connections; Access to Nature	People engagement programme (2 phases); People engagement plus 3-yr Park Ranger post			✓	✓ ✓
RSA	Royal Sun Alliance environmental fund	People engagement			✓	✓
TRRT	Fund manager and facilitator	River and wetland restoration; people engagement and access; policy development	✓	✓		✓

The MPRP case study evidence revealed a valuable role for non-public bodies (e.g. environmental trusts), to overcome funding conditions which require budgets to be spent within the ‘financial year’. These artificial spend deadlines may be problematic for project finance managers if they do not fit with work schedules, e.g. due to environmental restrictions such as bird nesting season etc. Under this scenario, the ability of voluntary sector organisations to act as a banking service and hold funds until needed, provided financial flexibility which enabled such conditions to be circumvented. Further funding management challenges and alternative options identified through case study observations are shown in Table 7.9. Some essential components to support external funding applications, highlighted by the NE advisor during interview and observations are also listed in Box 7.1.

Box 7.1 Essential planning approaches for external funding applications to support urban river restoration projects (Based on interview comments: External Funding Delivery Leader, NE, 2010)

- timetables for preparation and submission of grant applications;
- planned far in advance of delivery deadlines;
- sufficient design information and estimated budgets to give sponsors a realistic outline of proposals;
- preparatory work to meet strict criteria and application deadlines;
- researching the best fitting’ funding sources for individual project characteristics;
- filtering and identifying those with the best chance of success;
- tailoring individual grant applications by presenting ‘the right information in the right way’ i.e. ‘*..translating the information into funding language..’*

7.4.2 Partnership funding and voices

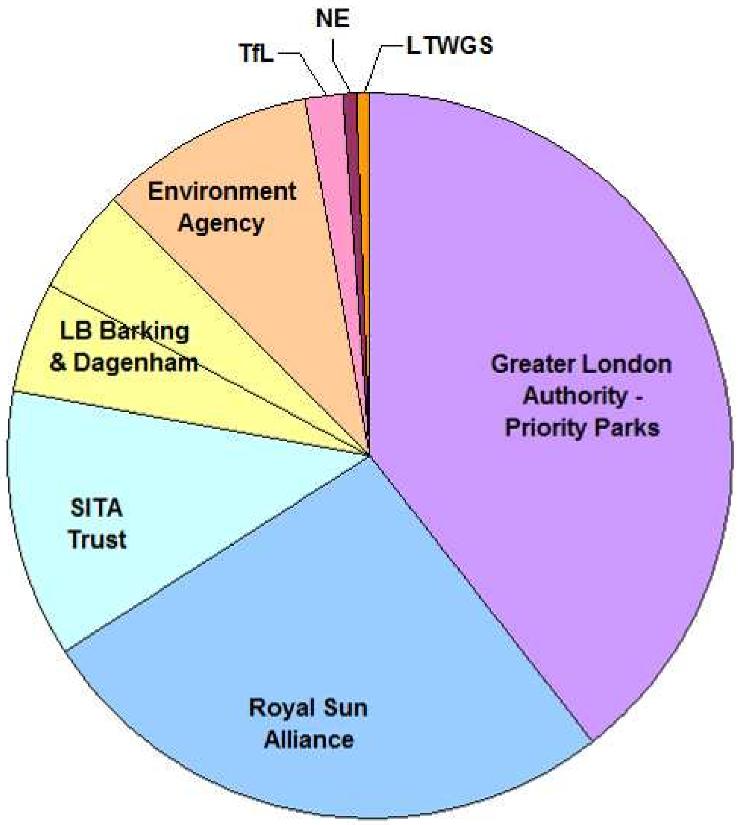
The partnership diagram shown in Figure 7.3 illustrates the configuration of organisations in relation to their roles within the project. What this diagram does not reveal are the different levels of stakeholder voices *within* the partnership. One unstated differential, which was however implicit within steering group meetings, was the relationship between the levels of sponsorship and voices within decision making.

Table 7.9 Challenges and alternative options for financial management of urban river restoration projects based on research evidence.

Financial management challenge	**Restrictions**	**Alternative Options**
Financial deadlines I	money must be spent by the end of 'financial year' (31st March) *(May be advantageous e.g. if there is money left to spend at end of year)*	Non-public body with flexibility to act as 'banking service' may be able to 'hold funds' into next financial term and released when needed
Financial deadlines II	Money must be spent before funding deadline (other than financial year end) *(Payment by invoice submission, so no 'banking' opportunities)*	No alternative options.
Sign off procedures / Limits on budgets	Higher level sign offs required for amounts over a fixed threshold (e.g. £50K)	To speed up process, amounts may be requested or distributed below the threshold, thus avoiding delays associated approvals procedures
Funding agreement conditions	Specific requirements linked with funding objectives	Negotiation with funding body may allow some minor revision of funding agreements. Generally limited or no flexibility as funds are specific to aims
Match funding requirements	Specific requirements to match funding with additional resources for same objectives *(May be specific to fund and inflexible)*	No alternative options *(In kind contributions are also eligible, e.g. as human resources in terms of employee or volunteer time)*

A simple analysis of the financial contributions provided by the MPRP funding organisations (illustrated in Figure 7.10) was carried out to gain an overview of the balance of sponsorship contributions. The association of each funding agreement with sponsor objectives and conditions (Table 7.8) also offers an opportunity to interpret the charts in terms of weighted influence upon the project outcomes. When the charts in Figure 7.10 are cross-referenced with the priority focal points shown in Table 7.8, the data indicate that capital expenditure was reasonably balanced between the river-floodplain and park environments. Whereas a negotiated concession within the GLA funding to cover shortfalls in the river restoration works had represented invaluable flexibility during a period of funding uncertainty, the securing of SITA Trust funding towards the end of 2010 allowed a renegotiation of GLA funds and reallocation towards

(a) CAPITAL (APPROX £1.02m)



(b) REVENUE (APPROX £0.4m)

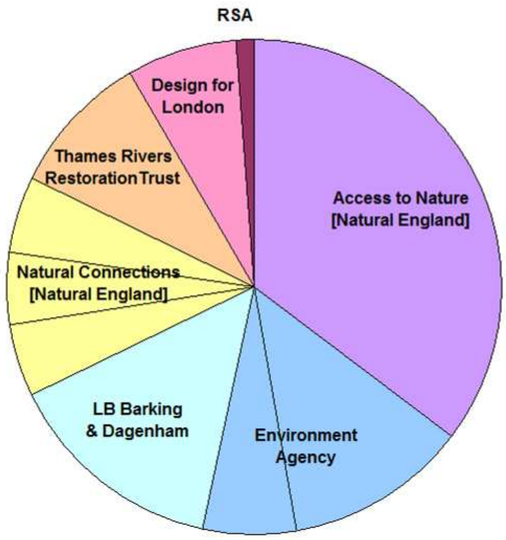


Figure 7.10 Pie-charts illustrating the different contributions made by funding partners to (a) capital and (b) revenue funding.

meeting wider park objectives. However, in the final stages, local concerns raised by a vocal minority within the community lead to a diversion of river-focused funds for increased security measures (i.e. installing a new and higher perimeter fence at strategic locations) and away from environmental enhancements (Conservation Officer, EA, Interview comments, 2011) resulting in a compromise for the river-oriented partners.

In terms of revenue funding, substantial but relatively smaller amounts from LBBD, EA, DfL and TRRT contributed to funding environmental consultancy services for scoping, feasibility studies, landscape and river designs. The largest proportion of revenue, managed by NE represented awards for people engagement through funds from Natural Connections (pre-capital works) and Access to Nature, representing a substantial legacy investment in the post-works engagement and monitoring programme including a 3-year full-time park ranger position.

7.4.3 Conclusions for urban river restoration financial management

Analysis of the data for the MPRP and other case studies suggests that, beyond the main remit to restore the ecological condition of degraded urban rivers, the wider socio-environmental character of an individual urban river-floodplain-park restoration will reflect the combined objectives of restoration partners, especially where clearly stated combined objectives are consolidated at the early stages, for example through ‘shared vision’ aspirations which are frequently revisited through the project delivery stage.

The objectives of sponsoring partners inevitably carry significant weight established via the funding conditions. However, the flexibility of funding partners in adapting conditions to match the overall shared aspirations was observed to be supportive to project finance managers and carried potential to enhance the objective integration process. Overall, the evidence demonstrates that the flexibility of partner funding agreements provides benefits to project finance managers who need to allocate funds to a range of fundamentally integrated components. The overarching aims of the three main case studies (Table 7.10) provide good examples of how each river restoration may be tailored to fit with locally and strategically relevant aims.

Table 7.10 Case study mission statement and objectives

Project	Mission statement / Objectives (Source)
Mayesbrook Park Restoration Project (MPRP)	*To transform Mayesbrook Park by improving biodiversity and enhancing the visual and aesthetic aspects whilst developing the environment for community and wildlife* *together with providing a future community resource resilient to climate change whilst reducing the financial burden on the client and delivering Phase 1 of the project by March 2012 within budget.* (MPRP Risk workshop report, Currie and Brown, 2010)
Ravensbourne restoration, Ladywell Fields (QUERCUS)	QUERCUS Project original aims and objectives: • *To increase use and enjoyment of the urban river corridor* • *To reduce crime and fear of crime* • *To improve habitats for wildlife* (QUERCUS Project Toolkit, LB Lewisham, 2009)
Brent River Park Regeneration Project (BRPRP)	Project objectives: • *To improve the density and diversity of freshwater fauna and flora of the river and its corridor, concurrently improving water quality where possible.* • *To improve the quality and diversity of terrestrial fauna and flora of the river margin and open space areas.* • *To improve the landscape of the area.* • *To improve public access to the river and surrounding open space, providing a green route to local schools and employment, and uniting the communities on both sides of the river.* • *To maintain flood protection to existing properties.* • *To improve the quality of the public open space, and encourage its use for both formal and informal recreation, including walking, cycling and jogging.* • *To reduce crime and create a safe and restored environment which fulfils community needs.* • *To engage the community, including local schools, in nature conservation and to establish links with the local intermediate labour market.* • *To improve health by encouraging walking, cycling and jogging through the space.* (BRPRP Objectives, LB Brent, undated)

In order to meet the management challenges for London's urban rivers and achieve ecologically successful and cost effective improvements, project financing strategies need to be responsive to the diverse socio-environmental opportunities associated with natural and human-oriented components of individual river-floodplain-park environments.

> *'..I think it's vital that environmental and social are both considered together in any park, in any urban greening, in any general environmental project, particularly in cities, because it's very different in cities … and it does need to be linked to people because otherwise you're not going to get funding or you're not going to be able to deliver what you want to deliver..'*
>
> (Environment Programme Support Officer, GLA, Interview comments, 2010)

The awareness of local qualities and attributes may also lead to wider opportunities and eligibility for new sources of funding (e.g. local or strategic private sector interests) and therefore budget enlargement. The diverse range of funding secured for the Mayesbrook project also provided partners with a demonstration of the potential for private sector engagement and a further example of best practice for future restoration projects.

> *'..This project is demonstrating is that you have to be flexible in a multi-partner project. That has always been case but as we go forward into a world of more economic and political uncertainty, that flexibility is going to be more and more important,…'*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

> *'..When I talk to other partnerships it's really good to be able to say , … 'had you thought of approaching…?', or 'we've got an example of….an insurance firm, sponsoring a large scale river restoration – climate adaptation project' so I think Mayesbrook's interesting from that point of view as well..'*
>
> (External Funding Delivery Leader, NE, Interview comments, 2010)

By pooling the expertise, knowledge and diverse objectives that characterise multi-disciplinary partnerships, innovative opportunities may be developed through different aspects of the project and matched to different funding sources. For example, a timely opportunity to link with the Olympics infrastructure investment in East London, led to an additional SUDS construction adjoining the Mayes Brook restoration.

7.5 Evaluating the environmental benefits and outcomes of urban river restoration governance

> *'..We've got to have these partnership ways of working, going forward. So that's one of the things we're trying to demonstrate you know, how to make these partnerships work, even with ten different people around the table, they can still work,..'*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

This chapter has attempted to investigate the role of multi-disciplinary partnerships in achieving ecologically successful and cost effective river-environment improvements through combined socio-environmental approaches. In doing so, the qualities and challenges of partnership, integration and interdisciplinary approaches have been used as a means of evaluating the evidence and outcomes observed during the project delivery programme of the main case study: the Mayesbrook Park Restoration Project (MPRP).

While delays that emerged during the MPRP programme prevented an assessment of the final environmental outcomes, those for the Ravensbourne (QUERCUS) and Brent (BRPRP) case studies (reported through Urban River Survey assessment in Chapter 4, section 4.4) both demonstrate measurable improvements in terms of river habitat quality.

The socio-environmental objectives of QUERCUS and BRPRP (Table 7.10) both included aspects to improve park user experiences and to reduce fear of crime. In both cases, ongoing stewardship and engagement activities have been running successfully since project completion, increases in park users are reported (LB Lewisham, 2009; Mbeke, 2008), and follow on projects have been successful in securing further investment for additional environmental projects (Waterlink Way and Parklands restoration, LB Lewisham, 2009; Brent River Park (Climate Change) Pavilion, LB Brent, 2010).

Many of the challenges of working in multi-disciplinary partnership and applying interdisciplinary approaches highlighted through the evidence presented in this chapter emphasise the complexity of integrating multiple perspectives and values which require additional time for the translation of concepts and development of common understandings to coordinate purpose and objectives. To achieve successful ecological outcomes for urban rivers within this complexity, therefore, requires clear and understandable overarching aims, which may be identifiably aligned with other non-river objectives. The important benefits of working through these complex urban river restoration planning and management challenges are demonstrated by the completed case studies as healthier aquatic habitat, more naturally functioning river reaches, improved park user engagement and attendance, and revitalised ecosystem services for local communities.

Within the partnership life-cycle, analysis of internal time factors reveal the importance of managing expectations and allowing additional time for differences in work culture, environmental cycles and knowledge exchange between the different disciplines and sectors during the consolidation and delivery stages, particularly when decision making requires the translation of unfamiliar concepts or technical details. The investigation of external time factors affecting urban river restoration reveals their complex multiplicity. The need for flexible views of micro and macro-scale temporal and spatial contexts was facilitated in the MPRP partnership by the long term experience of specialist fluvial geomorphology and landscape design consultants and river management experts. However, the research also highlights the importance of human time as a valuable resource in meeting urban river management challenges.

Voluntary measures included within the WFD River Basin Management Plans will be dependent upon contributions by local communities, business and industry for their delivery. The subsidiarity principles of the WFD therefore highlight the opportunity for further extension of interdisciplinary practices and inclusion of more community-focused partners within urban river planning and management. In the context of the Mayesbrook case study, winning funding to support a three year park ranger post enabled a highly valued component for both the local authority and EA (i.e. management and technical) project leads. The new park ranger post represents a major investment in future stewardship for the newly restored landscape to be supported by the voluntary sector Wildlife Trust, and drawing upon their environmental education and engagement expertise. This unusual addition to the Mayesbrook project was largely driven by the high profile of this project, its demonstration focus, and reflects a long term and sustainable perspective and a commitment by partners to long term monitoring and engagement objectives for the site (Conservation Officer, EA, Interview comments, 2011). It also represents significant example of 'best practice' to encourage the inclusion of similar legacy investments in future projects.

To conclude this chapter, a cross-examination of multi-disciplinary partnership characteristics against the urban river channel management challenges is provided in

Table 7.11 in order to identify positive options for managing the complexity of interdisciplinary approaches and achieving beneficial ecological outcomes for urban rivers. As Van der Windt and Swart (2008) suggest, the ‘vagueness’ of boundary definitions may offer a valuable flexibility in allowing common understandings for individual scenarios to be established between different stakeholders. However, the importance of maintaining a firm and clear focus on environmental needs and aligning these to other non-river perspectives through appropriate communication strategies, translating river science through audience-specific concepts and building a common vision is also fundamental to delivering sustainable outcomes for urban rivers.

The first two partnership qualities highlighted in Table 7.11 (Synergistic and Transformative/Innovative) underpin the research findings reported in Chapter 8 which are concerned with the integration of the environmental and social components of urban river restoration. The next chapter makes a detailed examination of the issues surrounding integration in urban river restoration planning and delivery, and especially the integration of multi-disciplinary partner objectives for the Mayesbrook case study.

Table 7.11 Summary of partnership processes and characteristics in relation to urban river channel management challenges and in the context of urban river restoration, Adapted from Mackintosh, 1992; Bailey et al. 1995; Downs and Gregory, 2004.

	Urban river channel management challenges			
Multi-disciplinary Partnership processes and characteristics *(underlying mechanisms)*	**Manage 'fluvial hydrosystem' from a 4-D perspective;**	**Integrate conservation with management objectives**	**Protect natural functioning**	**Undo degradation legacy**
Synergistic *(Integration)*	Include trans-borough partners; Emphasise catchment view; Link future vision to historic context	Integrate partners' objectives by highlighting common purposes to build shared vision	Integrate partners' objectives with natural processes and ecosystem services	Develop partners' combined understanding of past impacts and options for reversal
Transformative / innovative *(Knowledge exchange & creativity)*	Build awareness of catchment scale, corridor and floodplain connectivity	Exchange knowledge with non-river practitioners, mangers and public; Design bespoke approaches	Build awareness of functionalities and ecosystem services	Minimise engineering to allow river to 'engineer itself' & create new habitats
Budget enlargement *(Finances and resourcing)*	Coordinate developments and ecosystem benefits at catchment scale.	Emphasise ecosystem services associations; and extra efficiencies	Evaluate ecosystem services of surface water retention; hydraulic dynamism, habitat diversity etc	Identify economic benefits of SUDS, natural flood storage and soft engineering
Action oriented/ pragmatic *(Practical engagement)*	Define achievable practical goals. Demonstrate socio-environmental links through participation	Coordinate actions to meet common goals; Simplify and communicate links between river and wider goals	Define tasks to protect existing habitats, channels, margins or SUDS features	Define tasks to reverse negative impacts; Link with other remedial e.g. water/sediment pollution control projects
Responsive to new opportunities *(Inclusivity & flexibility))*	Identify and link with other projects in catchment; Co-ordinate to reduce fragmentation	Identify and initiate opportunities to co-ordinate diverse objectives	Identify and include interest groups with skills to enhance natural features. e.g. anglers	Identify damaged riparian sites with development and restoration opportunities
Record past achievements / evaluate activities *(Lessons learned & ongoing legacy)*	Record and evaluate river outcomes and benefits beyond reach scale	Establish / finance monitoring strategies from project budgets; design in adaptive management	Record and demonstrate natural functioning as a positive outcome (not a risk).	Publish pre- and post-project appraisals in case study reports and publicise headlines.

Chapter 8: Results V – An investigation of objective integration for urban river restoration projects

‘..I think it’s really important and really beneficial that you have that broader spectrum and that you have the environmental and social side of it – they both work, they’re mutually beneficial - a lot of social-environmental objectives - if you’re trying to do something environmental that delivers objectives for society anyway, and the other way around...’

(Environment Programme Support Officer, GLA, Interview comments, 2010)

8.1 Introduction

Urban river restoration projects offer valuable opportunities to integrate river- and human-oriented aspects of environmental regeneration within public open spaces and link to longer term sustainable visions of river and riparian stewardship.

The aim of this chapter is to shed light upon the mechanisms and challenges of environmental and social objective integration observed via the urban river restoration case studies. This chapter investigates the development of interdisciplinary processes through an examination of the emerging issues as multi-disciplinary partnerships engage in planning and delivering an integrated river restoration project.

Drawing mainly upon the evidence of the primary case study, the Mayesbrook Park Restoration Project (MPRP), this chapter presents an internal view of the perceptions and processes involved in the integration of environmental and social objectives through the participant observation and interview data. The integration of discrete social and environmental objectives through the urban river restoration delivery stage are investigated, to discover the extent to which multi-disciplinary partnerships are able to integrate objectives effectively whist delivering the maximum potential environmental benefits plus enhanced ecosystem services in the context of a wider park regeneration project.

Building on the observations of Scrase and Sheate (2002) (section 2.3.3), section 8.2 begins with an overview of different kinds of integration relevant to urban river restoration governance and delivery, and then examines those identified as most significant to the challenges of ‘integrated’ urban river restoration projects.

To set the scene for an evaluation of objectives integration, section 8.3 draws on evidence from MPRP meetings and interviews to provide a largely descriptive account of the origins and formal integration of the environmental and social objectives through the restoration planning processes (section 8.3.1). Exploring beyond the formalised processes, section 8.3.2 then investigates the issues which emerged through individual partner perceptions and expectations of objective integration and the consolidation of a ‘common purpose’. The emerging issues are interpreted through observations of partnership processes, in relation to multi-disciplinary partnership working and the challenges of managing integrated urban river restoration projects.

Section 8.4 first considers the corporate cultural context for partner institutions underlying their involvement in urban river restoration projects (section 8.4.1). The section next investigates the evidence for interdisciplinary decision making processes within multi-sector (i.e. multi-disciplinary) partnerships and three factors, raised by partners during interviews which they considered supportive to project data management and knowledge exchange, namely: meeting structure; visual imagery; and advocacy (section 8.4.2). Here the development of the MPRP monitoring strategy provides a working example to illustrate how a flexible partnership structure and interdisciplinary framework facilitated an integrated delivery challenge. Section 8.5 then summarises the main findings regarding objective integration and interdisciplinary decision making, highlighting examples of the integration of knowledge and expertise in practice across sectors and the river-floodplain-park environment.

8.2 Types of integration in urban river restoration

Of the fourteen different meanings of integration identified by Scrase and Sheate (2002, Table 2.12), all types of integration described are found to have some degree of relevance to urban river management. To be concise, summary points indicating the significance of each type and potential areas for future research are provided in Table 8.1. The meanings considered most relevant to multi-disciplinary partnerships, London river restoration and to support the integrated delivery of multiple objectives are expanded below. These include the integration: (i) of information resources (A), (ii) of concerns across environmental media (D), (iii) of different governance regions (E) and sectors (I) are expanded below.

Table 8.1 Summary of integration of environmental governance components relevant to urban river management. Adapted from Scrase and Sheate, 2002.

Meaning	**Main focus**	**Urban river restoration relevance**
A. Integrated information resources	Facts/ data	Increased integration in policy guidance e.g. LRAP, London Plan etc
B. Integration of environmental concerns into governance	Environmental values	Need for more integrated assessment through post project appraisals
C. Vertically integrated planning and management	Tiers of governance	Need for greater awareness of socio-environmental management challenges at ‘upper tier’ management levels; & to involve local stakeholders at earliest stages to encourage sense of ‘ownership’ and post project stewardship.
D. Integration across environmental media	Air, land and water	Need to increase knowledge of interdependencies and lateral connectivity of transitional river-floodplain-park environments; also integrate solutions between land and water pollution issues e.g. road runoff
E. Integrated environmental management (regions)	Ecosystems	Need more integration between boroughs across administrative boundaries. Develop catchment-scale perspectives for managers.
F. Integrated environmental management (production)	Engineering systems	Increased engagement by local industries represents an essential component of catchment management strategies : large/small businesses, through CSR programmes
G. Integration of business concerns into governance	Capitalist values	Increase engagement of private sector through CSR, voluntary engagement and sponsorship. And as above. Need to address conflicts through differences in work cultures and languages.
H. The environment, economy and society	Development values (Ecosystem Approach)	Integration of valuation reporting i.e. via ESA
I. Integration across policy domains	Functions of governance	Opportunities to identify more common purposes between departments dealing with aquatic / terrestrial / planning / climate change / health / leisure / sports etc
J. Integrated environmental-economic modelling	Computer models (Ecosystem Services evaluation)	Develop models that calculate ecosystem services evaluations
K. Integration of stakeholders into governance	Participation	As for C.
L. Integration among assessment tools	Methodologies / procedures	For example, Urban River Survey. Covered in chapter 3
M. Integration of equity concerns into governance	Equity / socialist values (Environmental Justice)	Social justice – review distribution of urban river restoration delivery. Need to tackle different degrees of stakeholder engagement and strategies in different demographic areas
N. Integration of assessment into governance	Decision / policy context	Need to include obligations for assessment and funding into planning rules etc

i. Integration of information resources

Within London, the integration of environmental information resources with relevance to urban river restoration has become increasingly prominent within the last decade (section 6.2). Integrated sources of policy information and guidance for London, such as the London Rivers Action Plan (LRAP, Environment Agency et al. 2009) and the London Plan (GLA, 2011, described in Chapter 5) are accessible within the public domain via the internet. The LRAP also provides a platform to actively maintain links between the EA, local authorities and river restoration practitioners (section 6.3). Nationally, the earliest case studies combining information of the environmental and social benefits of integrated river-park restoration projects beyond local circles were generally academic (Tapsell, 1995, 1997) or found within the specialist domains of river restoration (Environment Agency, 2000).

A note of caution regarding the selective reduction that may occur through integration of source data is however highlighted by Scrase and Sheate (2002). For practical reasons, the communication of complex integrated information requires reduction to enhance accessibility for potential readers. What is selected or omitted is based upon judgements informed by the editors own experience and expertise. As such it provides a reminder that in reality, all data analysis and reporting is to some degree affected by value judgments and that these risks need to be balanced by transparency, accountability, peer review, broad consultation and with reference to core objectives.

ii. Integration of environmental concerns across different media

The integration of environmental concerns across different media relates to the risks of exchanging negative impacts between aquatic, terrestrial and atmospheric environments. Environmental management requires awareness of the connectivity between such systems and can benefit from comprehensive baseline assessments and monitoring across connected systems at a range of scales.

The relatively under-observed outcomes of urban river restoration reflect a chronic lack of reach or catchment scale post-project appraisals (PPA; Downs and Kondolf, 2002; RRC, 2011), even though the application of generic river restoration techniques is often regarded as experimental due to site-specific response uncertainties, especially within highly modified channels and catchments. This phenomenon is generally associated with a lack of budget allocation beyond partnership termination stages. While some conditional restoration funding agreements require appraisal of specific indicators (e.g.

BAP habitat or indicator species), they represent a limited provision, insufficient for more informative function-oriented monitoring approaches.

Despite being highly recommended by regulators and river managers, monitoring and PPA remain an optional extra for most projects. The development of the MPRP monitoring strategy, based upon the guidance provided by the Practical River Guidelines for Monitoring Options (PRAGMO) framework (RRC, 2011) was enabled through prioritisation by the partnership and one funder's specification to have an integrated strategy in place before works commenced. MPRP partners also wished to demonstrate an innovative integrated monitoring approach as guidance for future urban river restoration projects (described further in section 8.4.2).

> *'.it's something that we need to do, we need to put in place a process … to do the follow up – looking at the monitoring data, the outcomes and then assessing: 'Were the environmental social and economic objectives achieved? Were they integrated? If not, why not? '*
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

The risk of redirecting pollutants between media may be associated with a lack of awareness of environmental connectivity and sensitivity to pollutant transfer pathways. The use of straw-bales to intercept suspended sediments carried in site run-off to prevent contamination of the Mayes Brook during site excavations demonstrated risk awareness by works managers and the application of a simple and cost effective strategy. Where more permanent sediment traps are created using sustainable urban drainage systems (SUDS e.g. reed beds) the resulting deposits require careful management if high levels of contaminants are present. Research into the best management strategies for contaminated sediments contained through SUDS techniques is ongoing. The variety of options, including vegetative remediation, barriers, or removal methods, suggests that solutions can be carefully designed to suit individual site conditions (Scholes et al. 2008).

iii. Integration of different sectors and regions

The benefits of developing common understandings of a healthy river system between environmental and non-environmental sectors are widely recognised by river scientists and practitioners (Meyer, 1997, Palmer et al. 2005). To provide effective support for inclusive decision making across disciplines and sectors, this requires active engagement and the provision of information at appropriate scales and detail.

Local involvement during the early stages of restoration in the Quaggy/Ravensbourne catchment demonstrates long term community interests in environmental outcomes and the ecological condition of their urban rivers.

> *'..For many years, we've had quite a few Thames 21 river cleanups in the river, … because Thames 21 were involved in the river catchment, they were very good and they got us involved and they instilled that extra bit of contact with the river, and then … it's great because they (Thames 21) came to us as Park User Group members and made us value I suppose the river even more..'*
>
> (Local resident, Friends Group member, Interview comments, 2010)

Evidence from interviews with QUERCUS stakeholders demonstrates how the knowledge of local enthusiasts was instrumental in their early engagement in this case study. However, it was also necessary for the EA to take a strong lead in emphasizing the best restoration design options to prevent a lack of specialist knowledge leading to negative environmental outcomes. A recent example of local pressure for inappropriate river works was identified on R. Misbourne, Chalfont St Giles where residents are keen to maintain flows on the groundwater fed chalk system by introducing an artificial lining (Hammond/RRC, pers. comm., 2011; www.misbourneriveraction.org/node/26).

The involvement of private companies in urban river restoration reflects a number of sponsorship mechanisms (e.g. Section 106 and environmental levies) and the rise of corporate social responsibility (CSR) in that sector. In the MPRP case study, the sponsorship and active involvement of insurance company Royal Sun Alliance (RSA) represented a significant benefit for the project, not only through funding contributions but also the employee volunteer days and provision of a marquee and catering for the project launch event during 2010. An investigation, commissioned by the EA, into methods to engage business and industry and deliver WFD voluntary measures also provides evidence of strategic planning in this area (Entec, 2008).

Within the public sector, the case studies demonstrated institutional integration both internally: between Local Authority departments for leisure and recreation, climate change, environmental health and planning (MPRP); and externally, between the EA and planning departments (QUERCUS). The value of sharing knowledge between Local Authorities undertaking urban river restorations was demonstrated through observed GLA Priority Parks meetings during 2010. A sub-group enabled river-park restoration managers to meet and exchange experiences and knowledge and provided a valued additional support network for Local Authority river restoration managers, and highlighted further opportunities for the improvement of trans-borough communications within single catchments (Environment Programme Officer, GLA, Interview comments, 2010).

> *'..in London you've got 33 Local Authorities, and you know the resource is shrinking, but there's no reason why you couldn't have .. a Local Authority officer who provides that technical expertise across three Local Authorities, like having your own in-house expertise…*
>
> *.. part of the reason why the Green Grid was developed was the recognition that a lot of land is owned by Local Authorities, but they don't look across those boundaries, they don't think about the relationship between this space and that space because that space is the other side of the borough boundary. The green grid helped to make sure that is looked at holistically, as a holistic piece of landscape. But the next logic is well why don't you have someone who's job it is to actually think about this* (catchment) *management across those boundaries ...'*
>
> (Environment Programme Officer, GLA, Interview comments, 2010)

The ecosystem services approach also highlights opportunities for organisations to recognise links more productively with other community practitioners through the cultural and aesthetic services provided by urban rivers e.g. health benefits or public art. The development and installation of artwork was observed as a powerful engagement tool in case studies, contributing to the connectivity of the rivers with the wider urban landscape and communities through education and health services e.g. design of route markers by local schools (Figure 8.1) and river related artwork in an adjacent hospital.

Figure 8.1 Schoolchildren developing artwork for route markers through Natural Connections engagement programme, May 2010.

Challenges for integration across sectors and regions may potentially arise through misunderstandings or expectations associated with different cultures or value systems. Integrating common understandings across a range of perceptions and expectations defined by different disciplinary, cultural or spatial starting points requires communication skills and relatively value-neutral and adaptive interpretation tools. Case study observations provide evidence demonstrating the challenges of maintaining communications at the right level of information both within the steering group and with other stakeholders in the local authority and wider community.

> *'.. managing the expectation of the project … there's still work to do because, although I'm one part of the council, there's a larger part of the council that actually looks after facilities – and although they're sort of aware – they're not really signed up to it as yet, so there's potential conflicts with them over the whole project…*
>
> *..I think the most important thing, and most difficult thing as well, is to keep all lines of communication open at the moment, open at the same time. It's very easy to focus on .. things that we know are beneficial aspects, but unless that's communicated and people are kept in the loop, then it just becomes a project in isolation and that's a real danger…*
>
> *..At the same time if you're constantly feeding information backwards and forwards people will lose interest, they'll get confused and they don't always want to know about the nitty gritty of what's happening and where. So it's a difficult nut to crack that one, and in many ways it's untested 'cos we don't know it's going to be a success until we do it....'*
>
> (Senior Park Development Officer, LBBD, Interview comments, 2010)

The next section reviews primary evidence for the MPRP case study to explore how partner perceptions and common understandings shaped the dynamics between individual and integrated objectives in comparison with observed partnership processes and environmental outcomes.

8.3 Integrating objectives: London and MPRP contexts

Based upon the evidence of the RRC and LRAP databases (section 6.3), the main motivations and aspirations for London urban river restoration projects (1980s-present), are habitat/biodiversity improvements and community demand/access and recreation (Table 8.2), indicating a strong socio-environmental focus for urban river environments. The databases revealed an average of three motivations per project suggesting substantial integration between environmental and social objectives.

Table 8.2 Priority motivations and aspirations for London urban river restoration projects

Motivations Source: RRC and LRAP (1983-2011)	**Aspirations** Source: LRAP (2008-2011)
• habitat improvement • community demand • fisheries • flood defence • landscape	• biodiversity enhancement • access and recreation • flood risk management • urban regeneration • climate change

In the Greater London context, the majority of river restoration works have been initiated mainly by the EA. The initiation of urban river projects is generally associated with a catalyst triggered by a local interest group or financial opportunity, often linked to flood engineering works or mitigation for a nearby development. In the case of the Ravensbourne (QUERCUS) case study, contact between the Ladywell Fields Park User Group (LFPUG) and the EA predated the QUERCUS partnership by several years.

> *'So going back a long way, part of the issue came about when we were approached by friends of Ladywell Fields which is the Park User Group, and that they wanted to improve the condition of the river, but they also recognized that there was various antisocial behaviour that was going on with the river.'*
>
> *'..with many projects: from initial concept to producing feasibility and then delivery, there often needs to be some kind of catalyst to take place. Part of that I believe was the redevelopment of the hospital which I did have a major play in and started getting people talking together'*
>
> (Biodiversity Team Leader, EA, Interview comments, 2010)

After interim stages including minor enhancement works in the original channel (funded via planning agreement (section 106) from the adjacent Lewisham Hospital Riverside wing development) two years later, a new weir bypass channel and flood storage area were created in Ladywell Fields (Biodiversity Team Leader, EA, Interview, 2010). The importance of the timing of opportunities and awareness of potential for river restoration in mobilising partner interests is reflected by local resident and member of the LFPUG and Quaggy Waterways Action Group (QWAG).

> *'.. QUERCUS you could have said almost evolved from the wishes, aspirations of the Park User Group and of course Lewisham in general ,… and the fact that I was vice chair of QWAG and I could see what had happened in Chin Brook* (restoration works) *and how we could do it again in a more urban situation…'*
>
> (Local resident/ Friends group member, Interview comments, 2010)

8.3.1 Historic context for MPRP objectives

To provide a context for objective integration, this section provides a brief description of the origins of the Mayesbrook project from the multiple starting points indicated by the MPRP timeline (pre-partnership stage).

Descriptions of the river-oriented and park-oriented project origins are provided, followed by a description of the convergence of river and park objectives.

i. River restoration objective origins

As described in Chapter 5, following the 2006 launch of river restoration strategies for north and south London, a clear statement of regional policy for London river restoration was announced with the LRAP launch in 2008. In support of these policies the EA also planned to create a pilot or 'flagship' project in Greater London that would demonstrate LRAP principles and techniques for urban river restoration (Conservation Team Leader, EA, Interview comments, 2009). Around that time EA catchment officers highlighted the Mayes Brook as a potential demonstration site. Meanwhile an informal group of partners with a potential sponsor approached the EA to discuss the possibility of identifying a suitable site to demonstrate river restoration, natural flood storage and wetland creation in the north London area.

> *'.. building on the legacy of restoration in the Lower Lee, we sort of knew it wanted to be in North London because of the political and financial support for that area so we commissioned the RRC to come down and to scope the Lower Lee and Roding'*
> (Conservation Team Leader, EA, Interview comments, 2009)

The RRC (commissioned by the EA in 2007) carried out a scoping assessment of potential river restoration sites using a questionnaire and 'decision matrix' which combined key environmental and social parameters (Table 8.3). These were each scored using either binary (Yes/No) or ranking (High/ Med/Low/None) criteria plus an estimation of 'percentage sub-catchment benefit' where applicable (RRC, 2007). The inclusion of both environmental and social semi-quantified scoring methods within the assessment clearly demonstrates a strong interdisciplinary approach at the site selection stage.

Table 8.3 Integration of environmental and social factors used in EA decision matrix for the identification of the LRAP demonstration project. (Adapted from RRC, 2007)

Opportunities to demonstrate	**Environmental**	**Social**
1. U/s grid reference and length of site (M)	✓	
2. Water quality improvements (i.e. potential to look at catchment wide improvements to mis-connections etc) ?	✓	✓
3. Highlighted in the London River Restoration strategies?		✓
4. Sustainable Flood Risk Management/flood storage?	✓	✓
5. Sustainable river restoration and FRM in the context of climate change	✓	✓
6. Space to include SUDs?	✓	
7. Reconnection to floodplain and creation of floodplain habitats?	✓	
8. Within regeneration area?		✓
9. Links with developers?		✓
10. Can it generate sustainable development/ attract new businesses (economic benefit)?		✓
11. Residential population within 1km?		✓
12. Number of Schools with 5km (if known)		✓
13. Will it help achieve the objectives of the Green Grid strategy (i.e. better transport, connections, footpaths etc)?		✓
14. Are there other open spaces nearby - please provide details (name, distance, location and what they are used for currently)	✓	✓
15. Ecological improvements in an urban setting?	✓	
16. Does the site contribute to (fit with) the GLA access to nature document?	✓	✓
ADDITIONAL INFORMATION:		
1. Available information - e.g. pre- project surveys, hydrological records, water quality, services, RHS, RCS etc etc	✓	
2. Potential partners (e.g. the Lee Valley Parks Trust etc) Comments/contacts please		✓
3. Funding opportunities		✓
4. If all sites suggested in each sub catchment/vision were completed would this increase the overall % benefit for the sub catchment? Water Quality / FRM / Economic gain	✓	✓
5. Additional comments to support or remove selection for short list		

Following the scoping assessment, the final selection of the Mayesbrook Park site was based upon a series of in-house EA consultations with representatives of the different internal teams covering flood risk management, water quality and conservation and the external partners, informed by the findings of the RRC scoping report and 'ground truthing' site visits.

The Mayes Brook site was then proposed by the newly established Thames Rivers Restoration Trust (TRRT) to potential sponsors, the Royal Sun Alliance (RSA) insurance who were working (through their global charitable partnership with WWF) to promote natural approaches to flood risk management, SUDS and climate change resilience. As well as providing the opportunity to demonstrate natural flood storage techniques in a densely developed urban area, Mayes Brook also met RSA criteria: to be within the specified area (NE London, near to Olympics and Thames Gateway development areas); in an area that would benefit socially from the river and flood plain improvements; and with good transport links to the City (to facilitate workers volunteer events).

> *'...our main objective was to demonstrate to the government, policy makers, anyone else who's interested the value of working together in a partnership where the private sector and 3rd sector and public sector work together on a project that will essentially benefit everyone including the local residents, the community.'*
>
> (CSR Programme Manager, RSA, Interview comments, 2010)

The pre-existing association between global insurance company RSA with global charity WWF was an important precursor to their involvement in the Mayesbrook restoration project. As part of RSA Corporate Social Responsibility (CSR) strategy, a combination of ongoing philanthropic work with the charity sector aligned with business interests relating to flood risk management was described as an important service delivery area (CSR Programme Manager, RSA, Interview comments, 2010). This combination of charitable and business motivations also led to the delivery of a new WWF/RSA policy document (launched in Westminster in January 2011) in parallel with sponsorship of the 'exemplar project' at Mayesbrook Park.

> '..(RSA) *signed up the TRRT to deliver this flood project which we saw as closely aligned to our business need by way of demonstrating better flood management risk for our customers and to demonstrate to our stakeholders and policy makers that as an insurance company we are doing more, in terms of preventative methods.'*
>
> (CSR Programme Manager, RSA, Interview comments, 2010)

As EA conservation officers had already highlighted the potential of Mayes Brook for restoration and BAP habitat enhancement, initial baseline surveys were planned and carried out by the EA in 2008. These data provided additional supporting material for communications with the riparian landowner (LBBD) in relation to the potential for brook restoration (EA Conservation Team Leader, Interview comments, 2009). Further detailed scoping studies delivered by river engineering consultants Jacobs were also commissioned by the EA with funding from the Flood Risk Management river restoration budget.

During the early stages of the river restoration component of MPRP, it is clear that the main motivations for initiating the brook restoration were expert-led driven by a combination of funding opportunities and the intention to identify a suitable demonstration site for restoration techniques and natural flood storage. In contrast to the QUERCUS case study the early MPRP planning stages did not involve local community representatives, however, several significant local social criteria were included via the RRC decision matrix as criteria for site selection.

> *‘..from the beginning we had very definite idea of what kind of project we wanted to do because we wanted to demonstrate some particular things like natural flood management vs concrete approaches; partnership working; innovative funding packages … also we had already entered into our agreement with RSA for funding for the right project, when we found it..’*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

ii. Park regeneration objective origins

In 2003 an audit of 30 parks in LB Barking and Dagenham identified Mayesbrook Park as one of eight ‘strategic parks’ prioritized for improvement under their Parks and Green Spaces Strategy (LBBD, 2004a; Senior Park Development Officer, LBBD, Interview comments, 2010).

As described in section 6.4.4 Mayesbrook Park is a designated Site of Borough Importance (Grade II) as Metropolitan Open Land. Although not actively managed for nature conservation, the southern woodland and lakes to the south of the park are also designated as a Local Nature Reserve. The LBBD Barking Development Framework (LBBD, 2007) also highlights Mayes Brook and Mayesbrook Park as important elements of green infrastructure and biodiversity which could benefit from restoration.

With the support of Design for London, Landscape consultants (Quartet Design) were commissioned by LBBD to undertake a green infrastructure study in 2008 to highlight the opportunities for connectivity to the north (with Goodmayes Park, in the adjacent borough of Redbridge) and south (to the confluence with the River Roding). The north and south green corridor reports explore the options and feasibility of developing routes along the riparian corridor for people and wildlife and in relation to the East London Green Grid and other urban greening projects nearby (Quartet Design, 2009a, 2009b). The recommendations of these reports have not been progressed to date, although discussions with neighbouring Redbridge may signal early interest in developing ideas in future.

> *'..sadly there's not been a lot of movement on that really. But you know there was the hope that perhaps some of the cycleway money could go towards it, but also the hope was to try and stimulate Redbridge to extract the Mayes Brook from the two parallel culverts where it goes through Goodmayes Park'*
>
> (Senior Landscape Consultant, Quartet Design, Interview comments, 2010)

iii. Convergence of River and Park objectives

The creation of the MBRP partnership in 2008 marked the convergence of the river and park components (Table 7.6). Community engagement and environmental arts and river workshops were soon underway with local schools supported via Natural England 'Natural Connections' programme, however the lack of sufficient capital funding for the integrated project meant that project planning remained at the feasibility and proposals stage until further resources were confirmed.

Active promotion of the Mayesbrook Park entry to the London Mayor's Help a London Park competition within the local community by LBBD during early 2009 (via leafleting, with petitions on the street, on council website and in local libraries etc) successfully secured £400,000 of funding for the project in March 2009. The winning proposals had a Climate Change Adaptation theme and included the restoration of the river, floodplain, lakes and woodland as well as wider park improvements including more bins, better seating and improved entrances. The overall proposal for the transformation of Mayesbrook Park promoted an integrated vision of revitalisation for the aquatic, semi-aquatic, terrestrial and social elements of the project to the wider community. Due to the scale of the park proposals, which included the restoration of the two lakes, and funding uncertainties it became necessary to split the project into two phases: with Phase I focused on the river restoration and wider park 'transformation' (as a primary condition of the GLA funding contribution) and Phase II on lakes restoration (Box 8.1).

Box 8.1 Outline of MPRP Phased delivery programme

Phase 1

- River restoration – up to 1 km of restored and realigned channel at 3 sub-reaches within Mayesbrook Park
- Re-creation of 1ha floodplain for natural flood storage
- Transformation of wider park environment: entrances, football pitches, bins, seating
- Creation of BAP habitat including reed beds and acid grassland
- New woodland and meadow areas – 3 ha of additional native trees planted plus 2 ha of wildflowers and acid grassland habitat
- Full time Park Ranger post – stationed within park running regular activities and events with LWT support

Phase 2

- Restoration of two lakes: De-silting and marginal habitat creation

Complementary to the RSA river-flood risk management oriented funding, the GLA Priority Park funding allocation represented more specific human-oriented capital investment that also supported the river restoration and integration of socio-environmental objectives through the climate change adaptation theme.

With two substantial funding allocations secured, project management and masterplan development could proceed and were progressed throughout 2009-10. The primary objectives of partner organisations (Table 8.4) defined their leading roles in terms of: river restoration (EA, Thames Rivers Restoration Trust), climate change adaptation /people engagement (NE), park transformation /urban design (GLA, LBBD, DfL), and wildlife conservation (LWT). Due to restructuring in the wildlife trust during 2010, the wildlife conservation focus was transferred to people and wildlife engagement, bringing closer links with delivery partners leading on engagement activities. A key objective for the Local Authority was to increase the number of park users and activities for people within the park (Senior Park Development Officer, LBBD, Interview comments, 2010). From 2009 onwards a people engagement programme was delivered through steering group partners (LWT, NE) and other voluntary sector practitioners (Thames 21, Studio 3 Arts). Throughout this period, master planning and river landscape design services were delivered by private sector consultants: Quartet Design (landscape architecture), and Jacobs Ltd (geomorphological engineering).

Table 8.4 Summary of MPRP partner objectives (Sourced from interviews & observations data)

Steering Group Partners	**Objectives**
London Borough of Barking and Dagenham (Project Lead Manager/ Senior Park Development Officer, LBBD, Interview comments, 2010)	*'get more people to enjoy the park for longer… giving people.. an incentive to go in the park….'* *' ...and then improving the environment: the BAP delivery is the main thing we want to deliver.'*
Environment Agency (Technical Lead Partner/ Conservation Team Leader, EA, Interview comments, 2010)	River geomorphological and ecological restoration ; Demonstration site for LRAP; WFD integrated objectives; Benefiting areas of social deprivation *'we don't think that river restoration should just be about ecology … a lot of our schemes are pigeonholed .... we wanted this demonstration site to be really multifunctional.'*
Thames Rivers Restoration Trust (Director, TRRT, Interview comments, 2010)	River restoration; Demonstration site for natural flood storage Climate change adaptation; achieve integrated social, environmental and WFD objectives *'.. to set up a demonstration project for what we call natural flood management: i.e. managing high water flows in ways that work with nature as much as possible, rather than against nature, because there is evidence from other places in the UK and other parts of the world that such naturalistic systems can work, can be cheaper than the traditional heavy engineering concrete approaches and also that they can provide other benefits such as biodiversity and landscape improvement and recreation for local people etc.'*
Natural England (NE Lead Partner/ Climate Change Advisor NE, Interview comments, 2010)	Demonstration site for Climate Change Adaptation; Urban greening; People engagement; Environmental access and education *'..to show that it delivers our desired outcomes* (for an NE integrated/ multiple objective project) *…. to show that adaptation can happen on the ground, .. as a demonstration project it contributes to the evidence as well as ... creating a natural resilience..'*
Greater London Authority (Environment Programme Support Officer, GLA, Interview comments, 2010)	Park transformation for local community and Londoners; Green infrastructure for CCA *'it's about improving it … for London's biodiversity, improving it for London people – so cleaner, safer, greener - and it's about transforming'*
Design for London (Urban Designer, DfL, Interview comments, 2010)	Improve urban design; Green infrastructure; Connectivity *'..supporting GLA on design related issues and because of the Green Grid there's several levels of environmental, flood risk, social targets that we're trying to hit as well ..'* *'..getting a good design, getting a vision created, deliver an exciting scheme ..'*
London Wildlife Trust (People and Wildlife, East London Area Manager, LWT, Interview comments, 2010)	Wildlife conservation; People engagement; environmental education *'..improving the park for biodiversity and community engagement in the park ,'* *'.. improving access, knowledge and understanding of wildlife for Londoners in order for them to grow to care and be concerned for it, ..'*

The ‘masterplan’ is the document through which individual objectives are combined into a single ‘vision’. This ‘living document’ represented a key reference point and interface between the MPRP partners, project managers and masterplan producers (landscape consultants) throughout the partnership life-cycle. Challenges arising for partners in the development of an integrated vision through steering group meetings and master planning processes are the subject of the next section.

8.3.2 Issues arising for objective integration (MPRP case study)

The purpose of this section is to investigate the challenges surrounding objective integration that arose through the partnership delivery stage. As delivery progressed, varying levels of interdisciplinary cohesion were observed as specific planning processes and components demanded more or less attention from partners. Although a review of the project finances in section 7.4 revealed that the river and park restoration components were relatively balanced, evidence from the interviews described how different ‘voices’ within the multi-disciplinary group were perceived as more or less prominent within planning processes. Issues relating to the balance of objectives, were highlighted particularly by incoming steering group members. These often reflected discrepancies between new partner expectations of the project, based upon available documents (e.g. feasibility reports, masterplan, etc), and their experience within steering group meetings.

Interview comments expressing perceptions of imbalances fell into three categories: (i) dominance by river restoration; or delivery gaps relating to (ii) climate change adaptation and (iii) people engagement (Table 8.5). These are discussed in relation to analysis of meeting observations and documentary (meeting minutes) evidence illustrated in Figure 8.2. Documentary analysis of the MPRP steering group minutes (2009 to 2010) reveals the coverage of core issues as recorded by the LBBD project manager. The relative coverage of: governance; finance; river/lakes; park; people/community within group meetings (identified by thematic coding) reflects the volume of entries recorded within the steering group minutes.

Table 8.5 Perceptions of dominance and absence of themes in steering meetings.

Perceptions	**Issues and Interview comments**
(i) Dominance by river restoration	=> Steering group meetings taken up with lengthy discussion around the river restoration and associated engineering works (project needs to) '*integrate more about the park transformation and about* (climate change) *adaptation rather than it just being river restoration'* (Climate Change Advisor, NE, Interview comments, 2010). *',,we have a lot of objectives that the river restoration will deliver in terms of biodiversity, in terms of social, in terms of all these things, but it is trying to make sure, trying to steer it so that the wider park is considered as well. '* (Environment Programme Support Officer, GLA, Interview comments, 2010) *'..there's so much of that, those sort of* (biodiversity-oriented) *disciplines in there, but I have to think outside of that, think about how the parks going to work and deliver a project people are going to be happy with at the end of the day...'* (Senior Park Development Officer, LBBD, Interview comments, 2010)
(ii) Delivery gap for climate change	=> Low level of attention given to climate change adaptation theme, and limited mention in master plan, lack of expression of shared understanding of climate change adaptation aspects *'..initially there was that challenge of it being branded as a climate change adaptation park and Natural England promoting it as such in literature and conversations but feeling that that wasn't actually happening in the planning of it, …'* *'…getting comments into the master planning process .. the adaptation bits and our outcomes from an organizational point of view into the masterplan I found quite challenging ..'* (Climate Change Advisor, NE, Interview comments, 2010)
(iii) Delivery gap for people engagement	=> Low profile at steering group meetings and unstructured engagement programme for the local community and stakeholders, lack of direct community representation within steering group '*there wasn't a worked up project idea of what we wanted to do with Mayesbrook this year for our engagement work; there wasn't any kind of aspirational project plan or anything like that.'* (incoming People Engagement Lead Partner, NE, Interview comments, 2010) => Compared to recognition of importance of social factors in London context: *'..it's about bringing that community on board and getting them to play their own role and I think we can't do any of it without the people … ... not in an urban environment in London without engaging the communities and making sure they've got this ownership and pride..'* (External Funding Delivery Leader, NE, Interview comments, 2010)

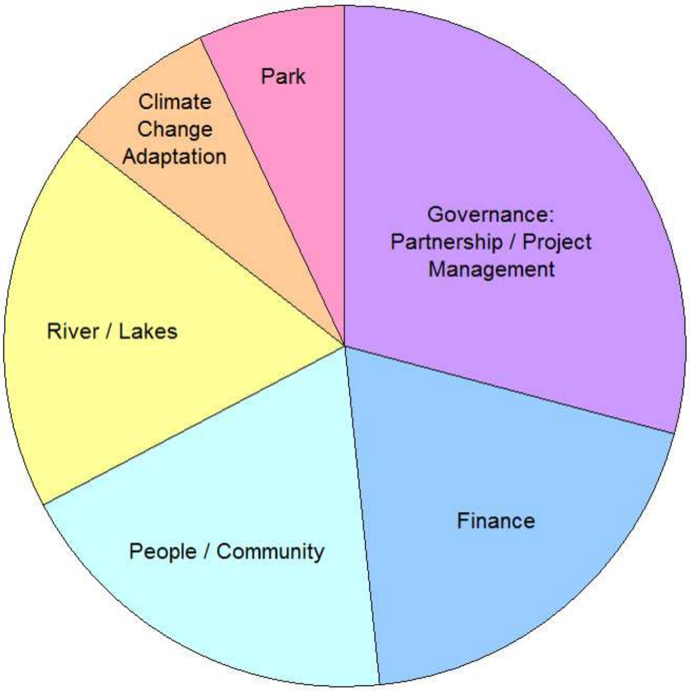


Figure 8.2 Pie chart illustrating coverage of themes during steering groups meetings based on analysis of LBBD meeting minutes.

The results indicate that governance (partnership, project planning and management issues) had most coverage in meetings (29%); finance, people/community (including events) and river/lakes issues were almost equally emphasised (around 20% coverage each), while climate change adaptation (CCA) and the wider park were least represented (around 7% coverage each). However, the integrated nature of discussions complicates the picture. Observation data confirm that discussions frequently centred on generic issues such as delays (e.g. relating to approvals, reporting), and short falls in funding. These discussions were often linked to design issues, constraints and opportunities at different river reaches within the park and associated options for wider landscaping.

Overall, the documentary, interview and observation data indicate disciplinary issues arising in relation to objective integration which warrant further investigation and may account for the perceived dominance or absence of key components by partners. Although not entirely clear cut, these issues appear to indicate imbalances between partner expectations and experiences of environmental/technical and social/engagement planning processes.

i. Environmental: technical planning processes

Several interview comments expressed a view that the proposed river works took up more steering group attention and time than expected, leading to perceptions that more voice was given to river-oriented than climate change adaptation or people engagement issues. Although the river and floodplain restoration were the agreed priority for the Phase I delivery, several partners' comments reflect the perception that the steering group was:

> *'..the Steering Group's tended to be a little bit introverted if you like and it's concentrated a little bit perhaps too much on the brook and that little bit rather than being slightly more expansive..'*
>
> (Senior Landscape Consultant, Quartet Design. Interview comments, 2010)

The MPRP partnership structure and objectives confirm that it was a *'very biodiversity oriented steering group'* (Senior Park Development Officer, LBBD, Interview comment, 2010), with four out of the seven MoU partner organisations having core environmental objectives (Table 8.4). However, the integrated nature of partners' primary and secondary objectives also demonstrate common ground relating to biodiversity, engagement and climate resilience issues. While a minority of steering partners had priority river-specific objectives (e.g. EA, TRRT), full steering group meetings frequently discussed specialist surveying and technical design requirements of the river works and often included additional environmental specialists advising or reporting on various technical aspects of the river restoration (e.g. Jacobs Ltd (river channel design), Thames Water (misconnections), RRC (monitoring), EA (water quality, flood, geomorphology, WFD), Queen Mary, University of London (URS)). These inclusive technical discussions often demanded additional time for knowledge exchange in order to support interdisciplinary decision making within the group.

> *'..all the necessary information.. ..has been shared in a very open way, all been made accessible to the partners. Everyone's been invited to comment and test the information to ensure that as we go forward that we're using the best information and reaching the right conclusion and making the right decisions.*
>
> (Director, Thames Rivers Restoration Trust, Interview comments, 2010)

The 'flagship', 'pilot' or 'demonstration' status placed upon the river-floodplain components also emphasised the importance of achieving successful river restoration outcomes from both technical:environmental and social perspectives. However, despite also having climate change adaptation demonstration status, prior to the monitoring strategy development, steering group meeting records confirm that climate change adaptation was referred to relatively infrequently (Table 8.5). When mentioned, there was no clear strategy for how climate change adaptation components were being delivered other than in vague terms: e.g. creating greater resilience for wildlife through river, floodplain and woodland habitat improvements. After joining the steering group in 2009, Natural England Climate Change advisor described their role as

> *… initially, to push the climate change adaptation aspects of the project. When I came into it although we'd got the report that said it's climate change adaptation of the park – it didn't seem to be coming out in any of the consultation stuff we were doing. When we had the consultation event in the park, people came along and said 'what's it got to do with climate change adaptation? …*
>
> *…and to integrate more about the park transformation and adaptation rather than it just being river restoration..'*
>
> (Climate Change Advisor, NE, Interview comments, 2010)

Research evidence supports the view that river-oriented technical and planning issues often dominated full group meetings. Interview data reflect the frustrations of some non-river-oriented partners regarding the extra efforts needed to represent non-river components in project planning meetings and documents (Table 8.5). However, river-oriented discussion also often linked closely to human issues, e.g. the water quality issues, directly associated with human health concerns and raising awareness of misconnections. Overall, analysis of meeting observation data indicates that the additional steering group time was frequently devoted to building consensus between partners regarding planning decisions for the river within the context of the wider park environment, but that this was not always immediately apparent.

> *'I think sometimes it's perhaps slowed the Mayesbrook process down a little bit, and I think we could have perhaps been a little bit further on than we are, but you know it's important to have everyone's contribution to the process and yeah hopefully that's going to be reflected in the final outcome..'*
>
> *'..we must never lose sight of the fact that the brook is an element within the overall park restoration which I think sometimes gets forgotten by the steering group.'*
>
> (Senior Landscape Consultant, Quartet Design, Interview comments, 2010)

Research findings therefore suggest that the inclusive approach to steering group meetings allowed dominance by river and technical issues to support inclusive decision making. While some partners recognised time spent on river-oriented issues as an essential knowledge exchange process, other (non-river) partners expressed concerns as this appeared to exclude discussion of the climate change adaptation and social (people engagement) objectives. During monitoring strategy development, a shift in focus led to a more effective integration of climate change adaptation as a cross cutting theme, relevant to the aquatic, terrestrial environmental and social components (section 8.4.2.).

ii. Social: engagement planning processes

From the early stages the river provided a focal point for social engagement and opportunities to liaise and engage with local schools. The Natural Connections programme delivered ‘people engagement’ schools activities (from 2009 onwards), led by LWT, Thames 21 and Studio 3 Arts. However, these components carried a relatively low profile at steering group meetings partly due to personnel changes affecting the engagement partners at Natural England (Natural Connections programme managers) and LWT. Subsequent concerns for the incoming NE engagement partner regarding the absence of outcome targets suggest a loss of continuity due to a lack of handover information. Assessment issues were subsequently addressed through the monitoring strategy planning workshops described in section 8.4.2.

Observation data confirm that social issues frequently featured within planning discussions (e.g. regarding consultation, perceptions of works etc), reflecting partners’ integrated objectives (Table 8.4), but also indicate the absence of local community representatives at steering group meeting level. Sports representatives were not observed at meetings and early attempts by the council to establish a ‘Park Friends’ group were slow to develop. Careful management of engagement with local residents and community groups reflected LBBD concerns of adverse community reactions linked to earlier objections to proposed river works.

Community concerns reflected (i) anxieties about security for properties backing onto the park and bordered by the existing Mayes Brook channel (Senior Park Development Officer, LBBD, Interview comments, 2010) and (ii) local youths and vandalism (for elderly residents living adjacent to the park (public meeting observations, October, 2010). These issues were highlighted as a priority concern by the lead project manager during interviews, and discussed but not specifically targeted for actions during steering group meetings. External community group (residents) meetings were attended by key partners (LBBD, EA, TRRT) to hear local concerns and provide progress updates. Within the steering group context, stakeholder engagement planning and reporting included (i) Natural Connections programmes, (ii) public consultation event (July 2009), (iii) Mayor’s park competition publicity and petition, (iv) community issue updates, and (v) the planning consultation. Many socially-oriented actions fell to the LBBD project lead, adding to pressures to deliver the Mayesbrook project alongside other duties and limiting the time available for greater community engagement investment. This approach contrasts strongly with other urban river restoration projects which highlighted the benefits of a dedicated community liaison role during project planning and delivery (e.g. the River Skerne restoration, Tunstall et al 2000).

> *‘..there’s project management support from the Capital Delivery Team and they are scrutinizing everything I do and making sure I’m not cutting corners or pasting sticking plaster on anything so you know there’s quite a lot of support on that side..’*
>
> *‘..we haven’t got time to go out and just do* (community) *workshops, because it would probably take up to 6 months to do that, .., you need to do it with different groups around the park and even then you’ll still end up on the same situation, that you have people that haven’t come along to the meetings, .., but when they see something going ahead they don’t like, they’ll come back to you.’*
>
> (Senior Park Development Officer, LBBD, Interview comments, 2010)

The LBBD project lead also managed coordination with other LBBD teams internally, with essential updates and decision making information provided to the steering group. Representatives of park maintenance did not attend steering meetings, but were kept updated by the lead project manager. During the later planning stages, internal managers became involved in the risk management planning processes ahead of tendering for the works contract. Links with the LBBD climate change teams also developed with the start of works on site.

8.4 Balancing objectives through interdisciplinary decision making

While current policy is supportive of integrated environmental planning, the evidence presented in section 8.3.2 highlights the challenges for multi-disciplinary partners in finding the right balance between social and environmentally oriented discussions within decision making processes. These include the apparent disconnections between perceptions of other partners’ objectives which appeared to be ‘pigeon-holed’ rather than being acknowledged as integrated components. For example, although river-oriented discussions were frequently related to social issues, they were perceived as dominant and excluding more socially-oriented discussions rather than regarded or used as a ‘bridge’. Also, the climate change components were not acknowledged or discussed in terms of their role as a unifying theme (to build resilience for wildlife and human communities) until the later development of the monitoring strategy. The evidence demonstrates how conceptual and linguistic barriers persist throughout the integration process, reflecting observations made by Bailey (2005) and Scrase and Sheate (2002) that perceptions stem from educational frameworks, disciplinary training and styles of communication.

> *'..I just think that very often, people coming at it with an environmental focus talk a different language to people coming from a social perspective, I think planners very often care all about sustainable development and less about ecosystem services and you get some who have a natural affinity or interest in that sort of thing, but that's not part of the job description...*
>
> *… far more environmentally minded people are about in proper jobs these days, compared to before, it's just you know there's no consistency in approach really..'*
>
> (Senior Sustainable Design Advisor, CABE, Interview comments, 2010)

The next section first briefly considers the corporate context for objective integration and the associated level of institutional support for partners involved in integrated projects (section 8.4.1) before reviewing some positive suggestions made by partners in interviews for facilitating knowledge exchange, integration and translation.

8.4.1 Corporate objective integration

Corporate uptake of sustainable development i.e integrated social, environmental and economic principles are increasingly reflected within mission statements across all sectors. For example, the aspirations of the EA corporate strategy '*aims to create a better place by securing positive outcomes for people and wildlife*' (Environment Agency, 2009c Corporate Strategy 2010-15) and were demonstrated through the site selection process (Table 8.3) and commissioned social surveys demonstrating a commitment to monitoring social outcomes alongside environmental assessments.

The river and wildlife trusts are similarly focused on people engagement in order to achieve their primary objectives for environmental conservation, restoration and protection. Meanwhile, local authorities are becoming increasingly involved in flood risk management, urban greening and climate change adaptation projects. For private sector partners RSA, the Mayesbrook project represented their first integrated socio-environmental project, reflecting a core business area (flood damage insurance) and their commitment to managing flood risk.

For experienced environmental education delivery practitioners LWT, the early steering group orientation towards capital (river:floodplain) works was seen as an inevitable precursor to community engagement works.

> *'.. a large focus so far has been the capital improvement works and rightly so, but it's coming to a stage now as the work is starting to happen you need to make sure that everyone living around the park is involved in it otherwise the sense of ownership is lost'*
> (People and Wildlife Area Manager, LWT. Interview comments, 2010)

For the environmentally-oriented organisations, localism agendas and opportunities for stakeholder stewardship in an urban context make social engagement highly significant for achieving subsidiarity, consensus and environmentally successful and sustainable outcomes (e.g. WFD delivery of voluntary measures). Although the MPRP partners demonstrated a strong motivation to integrate objectives, at the same time their objective-specific funding conditions were also observed to carry a significant influence upon objective integration and decision-making focus, as discussed in section 7.4.

8.4.2 Partner observations for improved integration

Interviewee comments included some positive examples and suggestions for the improvement of objective integration and interdisciplinary approaches. Two emerging themes: (i) meeting structure and (ii) visual media are discussed below in relation to the issues highlighted in section 8.3.2.

i. Meeting structure

Throughout partnership delivery the inclusive decision making approach (section 7.4.3.1) resulted in lengthy meetings involving the whole group, and included additional specialist meetings for monitoring, risk management, funding etc. Although no formal proposal for sub-group meetings was observed during meetings, interview comments suggested that a sub-group meeting structure might have been preferable.

> .*'..you could have a one hour steering group meeting with groups just reporting back and making key decisions about the whole project, …I don't really need to get involved in the specific design of the river restoration work, because the EA are there.'* (Climate Change Advisor, NE, Interview comments, 2010)

Development of the MPRP risk management and monitoring strategies each demonstrated knowledge exchange and interdisciplinary practice through inclusive decision making. The risk management process, supported by an external facilitator, enabled partners to identify, score and prioritise risk areas, and by consensus allocated ownership according to roles or responsibilities.

The monitoring strategy development, involved special (full) group meetings supplemented by focus (sub)groups coordinated by task managers. Two preliminary special meetings established partners' priorities for post-project appraisal including specific feedbacks required by sponsors (e.g. GLA - park transformation; NE - engagement; climate change adaptation; LBBD - park usage; BAP habitat; RSA - river:floodplain restoration). The specific requirement to complete the monitoring strategy before capital works began on site was a key factor in determining the working method applied to meet this deadline.

Two new monitoring strategies in development: (i) for river restoration (by RRC with EA and TRRT partners) and (ii) for climate change adaptation (by NE), provided the methodological starting points. The Pragmatic River Appraisal Guidance for Monitoring Outcomes (PRAGMO, RRC, 2011) method provided an adaptable framework of general principles which effectively met the needs of all identified themes. In 2011, four working groups were set up to progress monitoring strategy development (Figure 8.3). Following an intermediate collation stage by RRC and QMUL (reflecting PRAGMO development role and research interests) the integrated monitoring strategy was then reviewed and approved by the MoU partners.

The monitoring group structures and distribution of linkages between partner organisations and monitoring themes reflects partners' (inter)disciplinary interests (Figures 8.3 and 8.4). Both figures reflect the importance of the river restoration in the monitoring strategy planning and to the river-oriented partners (EA, RRC, TRRT). Associations between the components reflect the other partners' (inter)disciplinary interests (LBBD, NE, LWT), in particular, the interdisciplinary interests of LWT as key engagement and ecological education practitioners in all four working groups. Involvement in the collation process, highlighted the 'cross-cutting' significance of the 'People' and 'CCA' monitoring themes in relation to aquatic and terrestrial environmental objectives.

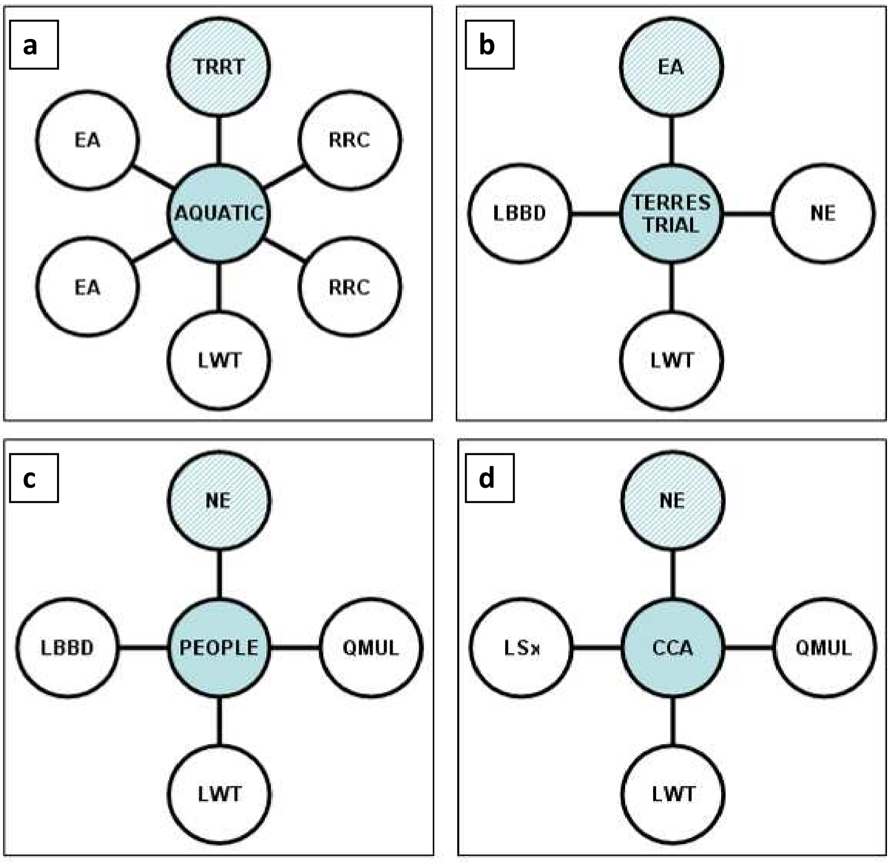


Figure 8.3 Structure of the monitoring party working groups for (a) aquatic environments; (b) terrestrial environments; (c) people and (d) climate change adaptation (CCA). Lead partners are shown as shaded circles.

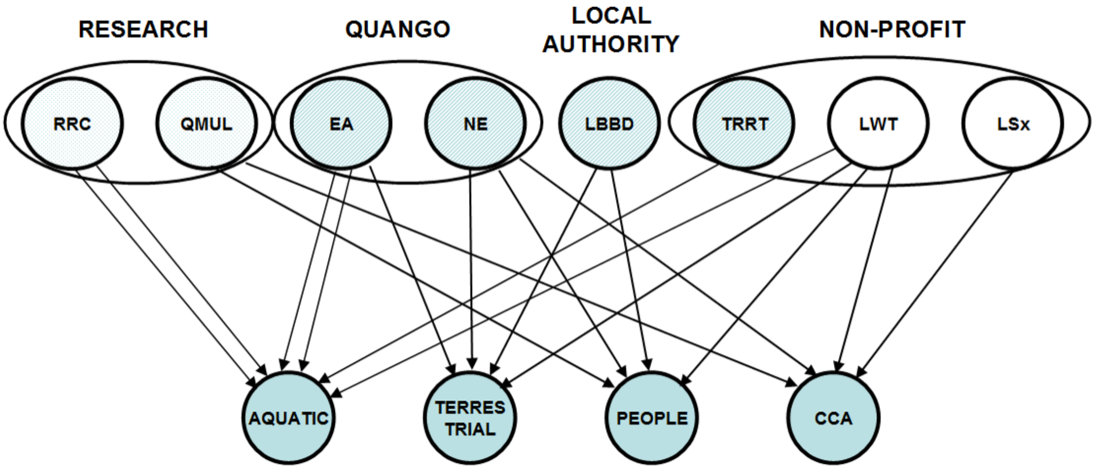


Figure 8.4 Diagram illustrating the linkages between partner organisations and monitoring themes: aquatic and terrestrial environments; people and climate change adaptation (CCA). Contributing organisations are grouped by sector and lead partners are shown as darker shaded circles, lighter shading indicates data collation role taken by researchers.

The interdisciplinary process of cross-referencing monitoring objectives and outputs through the PRAGMO framework produced a complex but comprehensive strategy. Coordination also allowed multiple monitoring objectives to be linked to encompass different purposes, e.g. targets to create BAP reed bed habitat, also meet CCA targets to improve species resilience through increased habitat diversity.

ii. Visual media

Visual media provide powerful knowledge exchange tools for interdisciplinary work. In particular, access to interactive maps can facilitate explanations and identification of parallel issues across spatial scales and within natural and built environments; discontinuities between physical (e.g. catchment) and social (e.g. administrative) boundaries; and ensure that 'new people at the table' are updated and rapidly engaged.

> *' it's amazing how many people congregate around a screen and say 'Yeah that's what I'm talking about, that bit there', and they start getting into it because it's live information it's all very useable and readily discussible information'*
>
> (Urban Designer, Design for London, Interview comments, 2010)

Colour print masterplan documents provided by MPRP landscape consultants (Figure 6.22) highlight the areas affected by river restoration works. The geography of Mayesbrook Park is split by the sports arena, with a smaller area for sports to the north (rarely featured in discussions, during events or site tours), large football pitches to the east of the park (light green) and ecological restoration areas around the west and south of the park (dark green) featuring the woodlands, brook and lakes (blue). The masterplan colour choices visibly highlight the aquatic and river environments (potentially reinforcing perceptions of river restoration dominance within the planning process).

For the QUERCUS project, the value of having a strategically placed map during a difficult meeting with 'upper tier' managers proved invaluable to building common understanding and overcoming communication obstacles.

> *'..I remember the Head of Capital Projects came along and the first question that X* (the EU Fund manager) *asked this guy was 'What relevance has this project got to everything else in Lewisham?' ..*
>
> *..fortunately, this man just said 'This is a catalyst', we had a map in the room of Lewisham, just by chance really, and he said 'Look, this is where the site is. We've got plans here, here and here – and this project is kick starting all of those', and you could see it was 'Oh, oh this is good – this is what we want to hear'..'*
>
> (European Projects Manager, LB Lewisham, Interview comments, 2010)

Two-dimensional matrices can also provide a powerful visual tool to reduce and present complex interdisciplinary information as demonstrated by the URS assessment tool (Gurnell et al. 2011, Figure 4.6) and PRAGMO (RRC, 2011). Various kinds of matrix methodology are encountered in interdisciplinary research, including 'wicked' problem solving strategies reviewed by Ritchey (2006b; 2008), as a constructive approach to finding solutions to complex open-ended problems. The suitability of matrices for the development of an interdisciplinary framework for urban river restoration is explored further in Chapter 9.

8.5 Conclusions for objective integration and interdisciplinary decision making

Successful objective integration was recognised within the multi-disciplinary MPRP partnership as challenging yet fundamental to achieving successful ecological and social outcomes.

> *' .. working in this interdisciplinary partnership has brought lots of different knowledge and background … you know it is very complicated but it will deliver a much more integrated approach to restoration and climate adaptation..'*
>
> (External Funding Delivery Leader, NE, Interview comments, 2010)

This chapter has provided an overview of the complexity and challenges of integrating multi-disciplinary objectives and perspectives within an urban river restoration partnership. By evaluating the evidence for objective integration in relation to the characteristics of interdisciplinary approaches (Box 8.2) clear parallels emerge.

Box 8.2 Characteristics of interdisciplinary approaches

(Pickett et al. 1999, Campbell 2002) introduced in section 1.4

- No clear framework or formula
- Involve efforts of MD teams and therefore take longer
- Require translation and interpretation of language and values
- Require open and constructive approaches to find novel solutions rather than critical obstructions

Based upon the evidence presented within this section, the three most significant influences upon successful integration in relation to achieving environmental outcomes for urban rivers, are identified as (i) levels and styles of knowledge sharing and exchange between different sectors and across administrative boundaries, (ii) coordination of environmental monitoring and appraisal across aquatic and transitional (semi-aquatic) environments, and (iii) identification of 'cross-cutting' themes to generate linkages and interdisciplinary bridges.

The main challenge for interdisciplinary approaches is that these require additional time to develop successful communication strategies and common understandings. Time-effective disciplinary knowledge exchange within inclusive decision making requires expertise in facilitation and the ability to steer overly technical discussions towards specialist working parties (with clear mechanisms for feedback) or more appropriate levels of information. The case study evidence therefore supports (i) the need for additional time investments for communication and expectation management identified by Pickett et al. (1999) and Campbell (2005), indicates (ii) the value of dedicated roles for lead management and (iii) the importance of facilitation by specialists in interdisciplinary approaches. Developing the use of centralised data 'hubs' would also facilitate knowledge exchange by allowing new and 'other' discipline or sector partners open access to baseline information and support decision making or bid-writing at key delivery stages.

> *'..- there's a lot of research work that's gone on – a lot of evidence related to this project – and it would be good to have all that information in one place and also things just like summary documents.*
>
> *… it needs to be something which captures all the evidence and the literature that's informed where we are for now. ….. the danger of partnership projects is that as individuals in particular move on from a project they've got papers that they've written on something that will quite often disappear with them…'*
>
> (Recreation Access and Quality Greenspace Delivery Leader, NE, Interview comments, 2010)

Knowledge sharing in the public domain was also recognised by partners as a potentially valuable way of sharing knowledge with local stakeholders, although not currently standard practice.

> *.. – and actually, that may be a way of working with the local community as well - you could have a page off the local schools website or something maybe with a podcast or a blog of what's happening at Mayes Brook and things so people can get regular updates or feeds..'*
>
> (Recreation Access and Quality Greenspace Delivery Leader, NE, Interview comments, 2010)

The use of working groups to manage the most technical river-oriented details, allowing more time within steering group meetings to address social and ecosystem services components, would consolidate partner organisations' sustainable development principles and an integrated restoration 'vision'.

Evidence of interdisciplinarity and transformation (of previously held views) through partnership synergies were identified during open discussion when different expert views were exchanged, blurring disciplinary boundaries, especially in terms of interlinked ecological and human benefits. For example, during the debate regarding fencing choices the debate over 'palisade' vs 'paladin' fencing became a moot point as the choice carried key budgetary implications. A clear design preference for the less opaque 'paladin' open mesh fencing expressed by urban designers, DfL was also supported by the EA as this would allow greater visibility, awareness and consideration of the restored river reach in an area which residents had requested remained fenced off due to security fears (Figure 8.5). For both organisations the issue represented a compromise with respect to residents' wishes, therefore choosing the right fence was a fundamental aspect of successful environmental design.

> *'For instance challenging the use of the palisade fencing which is a real simple thing but is an absolute, you know when you put that up you're completely going across the whole ambition about what is an attractive and exciting and transformation of the park …'* (Urban Designer, Design for London. Interview comments, 2010)

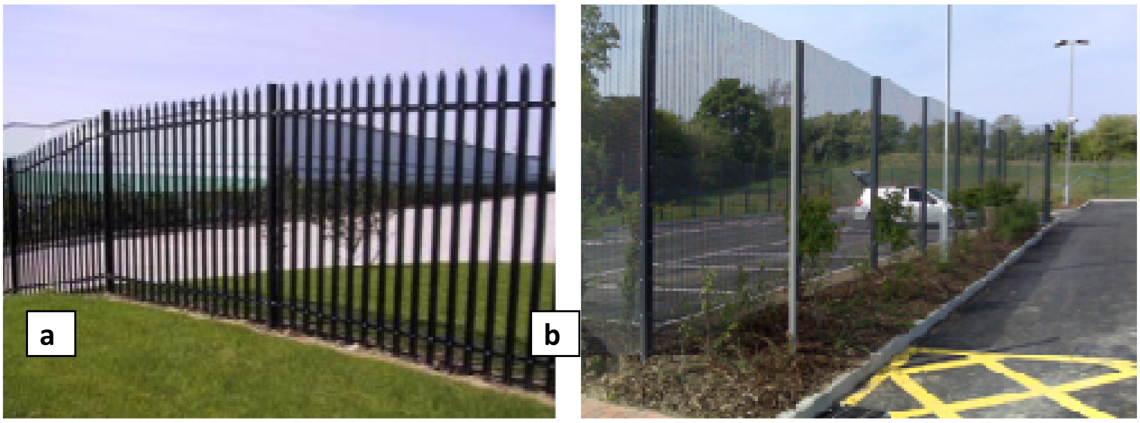


Figure 8.5 Contrasting boundary effects of (a) palisade and (b) paladin fencing (Source: www.autogatesolutions.co.uk).

Other partners expressed surprise regarding the EA interest in the fencing issue as they had not expected them to have a wider social perspective.

> *'..it's quite interesting, I mean obviously you know as much as anyone, their* (the EA) *main interest is the river, but they've got a social interest in that, so there's a lot of cross over between what's park and what's river in that respect…'.*
>
> (Senior Park Development Officer, LBBD, Interview comments, 2010)

The need for constructive approaches in interdisciplinary work, highlighted by Pickett et al. (1999) points the way to bridging the artificial boundaries generated by 'silo thinking' (Everard, 2011) and handling of issues in 'nested territorial containers' (Bulkeley, 2005). In this case, the overriding anxieties of a local minority coupled with the higher cost of the more aesthetic fencing forced the local authority to opt for the palisade security fencing (Conservation Officer, EA, Interview comments, 2011). This example demonstrates the potential for synergy between the built and natural environments and highlights the importance of winning support from local residents and including representatives of local interests in meetings from the earliest planning stages.

The identification of 'cross cutting' themes as transitional ground between disciplines, whether defined by (experiential or expert) knowledge or roles, reflect areas where interdisciplinary approaches can define connections and enhance existing knowledge. The value of 'vague areas' existing within 'boundary zones' highlighted by Van der Windt and Swart (2008) is challenging for a scientific approach but allows room for interdisciplinary approaches to be constructive, to 'rewire' connections and generate solutions to meet the unique integrated nature and purposes of projects. These ideas are developed further in Chapter 9 through a synthesis of the results presented in chapters 4 to 8.

Chapter 9: Synthesis of conclusions and research recommendations

9.1 Introduction

The primary aim of this thesis was to investigate the interdisciplinary nature of assessment, planning and management of urban river restoration in London. The research design employed a range of physical and social science methods in order to gain an understanding of the roles of and interactions between the multiple environmental and human elements influencing urban river condition and management. The results presented in Chapters 4 to 8 have drawn upon a wide variety of evidence and provide a diverse set of findings encompassing different environmental and social aspects of:

(i) measuring, analysing and communicating the integrated environmental (bio-physical) and social (anthropogenic) qualities of urban rivers; and

(ii) multi-disciplinary partnership working practices to restore and manage urban rivers and potential approaches to facilitate integration of disciplinary perspectives or work with disciplinary (as cultural or conceptual) differences.

The following sections provide a synthesis of these results in order to identify emerging knowledge and areas for further research. Section 9.2 first discusses the main findings in relation to the research questions highlighted in Chapter 2:

- *To what extent can ecologically successful and cost-effective river environment improvements be achieved through integrated approaches to urban river assessment, planning and management?*
- *To what extent are current environmental governance models and multidisciplinary partnerships able to deliver benefits for urban river environments and enhanced ecosystem services to society through urban river restoration projects?*
- *To what extent can integrated assessments of urban rivers (such as URS and ESA) provide tools to share knowledge and support decision-making for urban rivers and support the delivery of environmental policy objectives?*

- *To what extent are current environmental information resource bases and knowledge exchange processes providing support to practitioners for assessing, planning and managing integrated urban river projects?*

Section 9.3 describes further insights gained through the research in relation to integrated river restoration and interdisciplinary partnership in practice. The final section (9.4) provides recommendations for further research.

9.2 Synthesis of research findings

Given the multi-scale heterogeneity of urban river environmental and social characteristics, the following responses to the research questions raised in Chapter 2 adopt a cautious approach to generalisation, whilst seeking to identify common themes drawn from the cross section of research evidence sourced from Chapters 4 to 8.

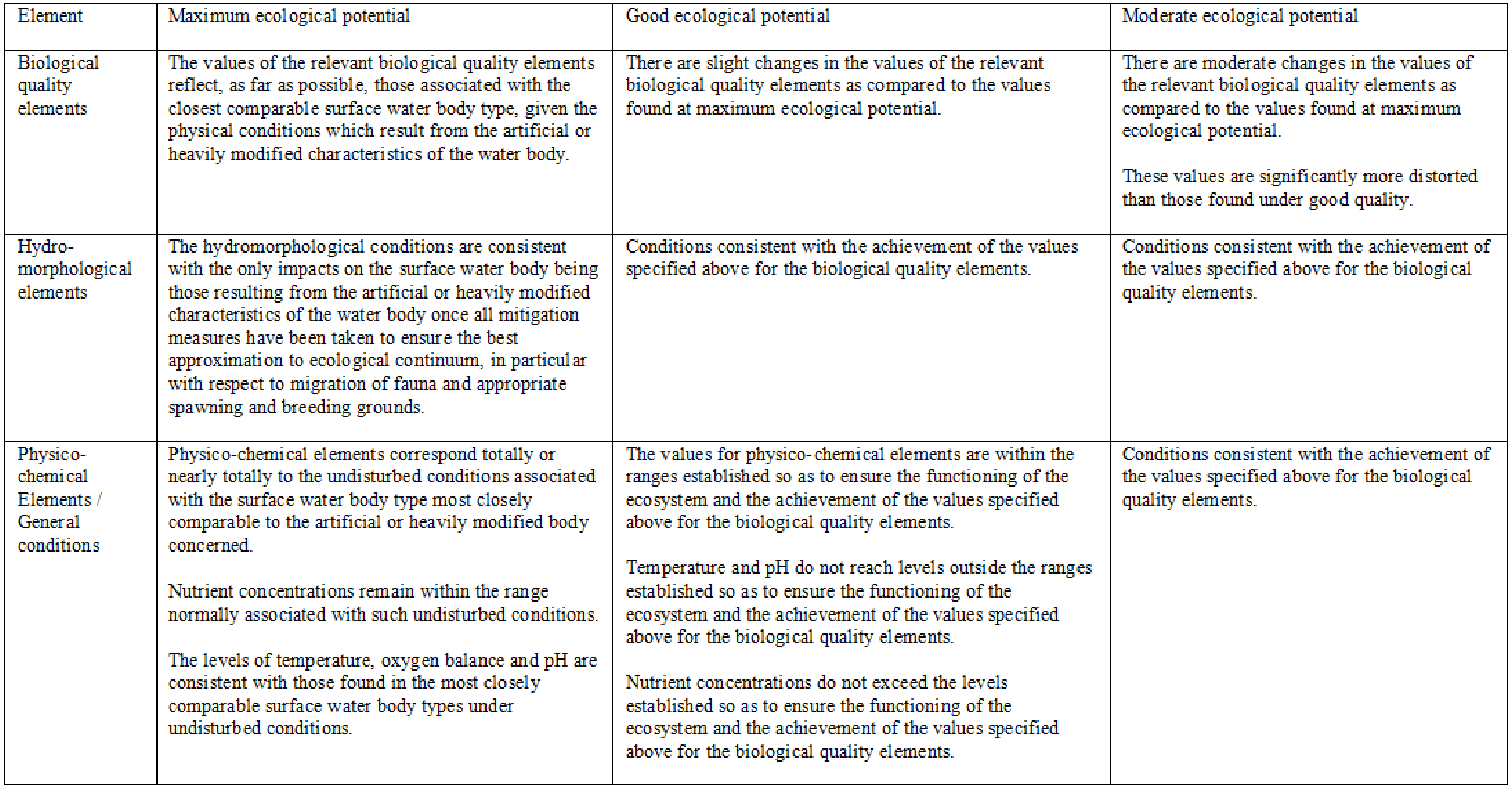
9.2.1 Achieving ecologically successful and cost-effective river environment improvements through integrated approaches

Achieving ecological success through urban river restoration

Within the current environmental governance context, measures of ecological success in European river systems are guided by the Water Framework Directive (WFD, Chapter 5). Therefore for river practitioners working in urbanised catchments across the UK, the most relevant assessment of ecologically successful environmental improvements in heavily modified rivers will be measured in line with the WFD requirements for Good Ecological Potential as shown in Table 9.1. Here WFD guidance indicates the importance of taking mitigation measures for physical elements in support of an ecological continuum, with particular reference to the physical requirements of aquatic organism life stages, such as migration, spawning and breeding grounds, with only ‘slight changes’ in the value of quality elements classed as ‘good potential’ when compared to ‘maximum potential’ (EC, 2000 p.50).

The acknowledged importance of habitat patches to aquatic organisms and functional ecosystems (Pringle et al. 1988, Ward et al. 1999, Thorp et al. 2006) places meso-scale habitat assessment methodologies, such as the River Habitat Survey (RHS) and Urban

Table 9.1 Definitions for maximum, good and moderate ecological potential for heavily modified or artificial water bodies.
Source: Water Framework Directive 2000/60/EC



Element	Maximum ecological potential	Good ecological potential	Moderate ecological potential
Biological quality elements	The values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the water body.	There are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential.	There are moderate changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential. These values are significantly more distorted than those found under good quality.
Hydro-morphological elements	The hydromorphological conditions are consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Physico-chemical Elements / General conditions	Physico-chemical elements correspond totally or nearly totally to the undisturbed conditions associated with the surface water body type most closely comparable to the artificial or heavily modified body concerned. Nutrient concentrations remain within the range normally associated with such undisturbed conditions. The levels of temperature, oxygen balance and pH are consistent with those found in the most closely comparable surface water body types under undisturbed conditions.	The values for physico-chemical elements are within the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Temperature and pH do not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

River Survey (URS) in a strong position for supporting the achievement of ecological objectives under the EU Water Framework Directive (Newson, 2002). However, the recording of features does not equate to measuring process or good ecological function (Newson, 2002), and there remains considerable uncertainty regarding the potential responses or trajectories of change over time, following restoration or enhancement interventions (Gregory et al. 1992, Clark, 2002, Suding and Gross, 2006; Dufour and Piégay, 2009).

The findings presented in Chapter 4, show how the Urban River Survey PCA outputs can be used to map differences in physical habitat diversity in relation to different levels of channel engineering. The bio-physical differences are compared at the reach and catchment scales to investigate different types of habitat:engineering associations which may emerge as a result of different engineering approaches applied historically across a catchment or resulting from more recent restoration works. The results presented for the catchment scale comparison of the Mayes Brook reveal the potential for different types of habitat:engineering association to appear as clusters on the PCA plot (Figure 4.26). Although the URS data analysis presented in this thesis does not include broader geomorphic information regarding distance from source, slope or underlying geology, there is scope within the survey to gather these data through desk studies and to include this information in catchment scale interpretations of the URS outputs. Consideration of catchment scale impacts upon the bio-physical properties of urban rivers is vitally important for an integrated management approach (Brierley, 1999; Bressler et al, 2008).

The surveyed reaches of the Mayes Brook catchment were all heavily urbanised and disconnected from the superficial and underlying geology, therefore the channel and riparian zone engineering represented the overriding controls upon habitat features before restoration. In an urban context, it is vital to review URS data in relation to wider catchment controls, and especially longitudinal and lateral connectivity. The UK is considered to be a highly urbanised country with over 80% of the population occupying approximately 10% of land classified as ‘urban’, of which over 80% is located in the London region (Pateman, 2010; Dixon, 2009), reflecting statistics in other industrialised nations (Grimm, et al. 2008). The physical pressures on rivers observed within Greater London, are likely to be representative of those within urbanised areas in the UK and in the wider global context for temperate regions (as an historic or modern industrial legacy or to manage flood risk), although regional variations may emerge as more URS data are gathered in different locations.

An evaluation of the bio-physical responses to restoration works carried out on the rivers Brent and Ravensbourne using the Urban River Survey (URS) indicates clear differences in the post-project outcomes (section 4.4). The URS PCA investigations of two sets of paired reaches (chosen to represent pre- and post-restoration conditions on each river) demonstrate bio-physical differences in relation to the type and diversity of habitats, shown by the difference in plotting positions in relation to the PC-axes (Figure 4.16). The contrasting positions of the pre- and post-restoration works for each river site suggest a variety of possible responses to different restoration approaches and changes over time. The plotting position of the more mature river Brent post-restoration stretch reflects the presence of developing riparian vegetation as well as active geomorphic in-channel features, whereas the immature post-restoration condition of the Ravensbourne stretch, with a lower diversity of riparian and in-channel physical features is indicated by the higher value for PC2.

These findings suggest that the gradients of river characteristics represented by the two PC axes may provide a useful tool to indicate different stages of riparian vegetation maturity and geomorphic adjustment in terms of physical habitat diversity. Furthermore, by tracking different stages of habitat adjustment following restoration works via temporally sequential stretch plotting positions on the 2-dimensional PC plot, the URS matrix also offers an effective means of presenting and interpreting bio-physical responses over time (section 4.4.2). The full potential of the URS matrix to serve as a tool to appraise and communicate temporal geomorphological responses to channel interventions over time has yet to be explored.

Comparison of the plotting positions of the post-restoration case study stretches (for the Brent, Ravensbourne and Pool) on the URS PCA plot (Figure 4.27) described in section 4.6, demonstrates broad differences in the engineering and habitat characteristics of these individual sites at different time intervals following major restoration works. The differences in adjustment are strongly associated with the style of restoration works: ranging from fully reinforced with no lateral connectivity but significant in-channel physical recovery (pool scour and bar formations), to predominantly no reinforcement with good lateral connectivity, riparian recovery and signs of morphological adjustment (pool-riffle maintenance, bank erosion, sediment recruitment and bar formation). Although significant contextual differences exist between each site, not only in terms of the restoration techniques employed, distance from source and upstream catchment influences, each location demonstrated local adjustment indicating the potential for hydraulic processes and functionality to improve local channel morphology within a range of engineering types where sediments are available. Although access to detailed catchment scale data may be limited, the importance of interpreting the URS results in relation to broader catchment engineering and sediment mobility as well as local influences is emphasised as paramount for long term adaptive management.

Further investigation of the trajectories of change for restored reaches interpreted through the URS matrix is recommended as an essential component of post-project appraisal so that scientific investigation of bio-physical responses to restoration and enhancement works might become increasingly robust and examined more directly in relation to biological components. With this in mind, the URS outputs demonstrate a valuable measure of the variety and extent of habitat features and overall habitat character within the context of the reach engineering, the contributing catchment and other physical controls (e.g. hydrological and morphological). Furthermore, in relation to the WFD objectives, the comparison of the positions of the River Brent pre- and post-restoration stretches on the URS matrix from an area representing low habitat diversity to one of high diversity effectively demonstrates an improvement in bio-physical condition and therefore a positive ecological outcome for that restored site resulting from the removal of concrete reinforcement and reintroduction of meanders and heterogeneous bed profiles along that stretch.

The physical science findings are also supported by ethnographic research evidence (interview analysis, section 4.6 and the review of case study histories and management practice contexts, section 6.4) which reflects a gradual change in practice following the paradigm shift towards softer engineering approaches which first emerged during the 1980s. A focus on the reinstatement of naturalised river functioning in line with WFD requirements now aims to allow the development of more diverse and dynamic channel forms and features, as long as essential infrastructure is not compromised, such as on the River Brent in Tockyngton Park, where underground cables were protected from excessive channel adjustment by strategic partial reinforcement using concealed riprap and willow spiling (section 4.6.1). In relation to the management challenges for London rivers (highlighted in sections 2.3 and 7.2), evidence of the delivery of practices which favour the restoration of river function and the creation of more habitat diversity provide a solid basis for the argument that current integrated approaches are continuing to deliver bio-physical changes which increase habitat diversity and support the achievement of ecologically successful outcomes within historically damaged urban river reaches, as demonstrated by the post-restoration outcomes for the case studies on the Brent and Ravensbourne.

As well as introducing new ecological objectives for water bodies (e.g. Table 9.1), the Water Framework Directive also includes an emphasis on cooperation and public involvement:

> *'The success of this Directive relies on close cooperation and coherent action at Community, Member State and local level as well as on information, consultation and involvement of the public, including users'* (EC 2000, para. 14.)

These principles clearly embrace the concept of integrated river management which includes social elements. As such, the WFD represents the eventual infiltration into policy of a much earlier recognition of the importance of integrating social criteria into integrated river management. For example, a review of literature spanning 1970-80s by Downs et al. (1991) provides important examples of river management 'provision objectives' which include 'leisure' (as recreation or angling) in 6 out of 21 papers listed, dating back to 1978. Contemporary evidence of integrated objectives driving urban river restoration projects presented at the local (case study histories, section 6.4) and London-wide (RRC/LRAP data, section 6.3) scales supports the argument that a combination of environmental and social motivations has been driving London river restoration since the 1980s. However, less is known about the success and sustainability of the outcomes of these examples of integrated river restoration.

The rising prominence of social aspirations alongside priorities for habitat improvement observed in the regional scale data for Greater London coincides with the increased engagement of local authorities in urban river management and restoration practices, supported via the London Rivers Action Plan (LRAP, Figure 6.2). The research interviews and observations presented in Chapters 7 and 8 demonstrate the involvement by local authorities in the restoration case studies, which represents a positive step forward for the integrated management of aquatic and riparian habitats, and amenity interests in public open spaces. The range of socio-environmental objectives for the case study partners (Table 8.4) indicates significant progress towards embedding multi- and inter-disciplinary approaches into urban river restoration, previously regarded as part of the 'knowledge deficit' for restoration practitioners (Eden and Tunstall, 2006).

Achieving cost-effective outcomes through urban river restoration

The assessment of overall cost–effectiveness of urban river restoration is a complex task due to the current limitations and uncertainties of ecological valuation methods. The challenges involved in calculating a quasi- or direct valuation for environmental services provided to society are demonstrated in section 4.7 through the results and critique of the Mayes Brook Ecosystem Services Assessment (ESA). In contrast to earlier EA rural studies (e.g. Everard, 2009), the outcomes of this prototype model of urban river ESA demonstrate a greater significance for regulatory and cultural ecosystem services to urban communities. However, high levels of dependency upon a small number of valuation calculations plus numerous (explicit) assumptions present a weakness in the current methodology that warrants further research attention.

Monetising the full range of ecological services (section 2.4) is widely recognised as being problematic and beyond current methodological capabilities (e.g. TEEB, 2010a, Kaval, 2010), thus only a tentative measure of the economic benefits of environmental restoration can currently be achieved. The uncertainties associated with calculating the full costs of ecological services, including a lack of definitive guidelines and the subjective nature of approaches such as the ‘willingness to pay’, inevitably result in a partial estimate of the value of environmental benefits. For example, many ecological services provided by biodiversity are acknowledged as ‘invisible’ or poorly understood (TEEB, 2010a, Cornell, 2011). However, it is vital that the ecosystem approach is not undermined or disregarded due to current methodological limitations. The weakness of taking an economic approach to assessing cost effectiveness of river environment improvements is due to a greater reliance upon implicit than explicit evidence, however this is inherent within environmental economics evaluation methods which are combined within the ESA approach.

The evidence presented in this thesis (section 4.7) and the literature (e.g. Everard and Moggridge, 2011, Cornell, 2011) suggests that cost effectiveness evaluation for environmental restorations requires a more inclusive form of credit system, involving the integration of monetary and non-monetary e.g. ‘quality of life’ benefits. The case for creating an alternative non-monetary ‘valuation’ mechanism or credit system, which could for example encompass traditional financial and other qualitative or semi-quantified measures of socio-environmental benefit, is clear and represents an area of urgent need and potential future research (section 9.4).

Evidence of the diversity of sources and approaches to financing urban river restoration is demonstrated via the historic and case study data presented in sections 6.3 and 7.4. These examples demonstrate the wide range of potential public, private and voluntary sector sponsors with a history of financing integrated urban river restoration projects.

The research findings presented in section 7.4 clearly demonstrate the benefits of negotiating flexible conditions for environmental and socio-economic objectives with major funders, in the context of the overall masterplan. For example, enabling the allocation of funds across a range of objectives in order to balance the more constrained and objective-specific conditions of minor funders can help to fill funding gaps. A valuable facilitation role for third sector partners was also observed whereby non-public bodies were able to act as ‘banking’ facilities for budgets that needed to be discharged by the public authorities before the end of a fixed financial period, thus offsetting current problems associated with artificial spending regimes governed by the financial year rather than the project life-cycle.

The overall attraction to partners in taking a combined socio-environmental approach to urban river restoration is evident as this resonates strongly with sustainable development principles, ecosystem services (e.g. natural flood storage and SUDS), and institutional objectives across all sectors (section 8.3). It is noted that the increasing involvement of private sector organisations in sustainable development projects, such as urban river restorations, might be interpreted as a business sector judgement of the cost-effectiveness of such urban environmental investments. In relation to the achievement of sustainable solutions to meeting WFD policy requirements (section 5.3) and river management challenges (section 7.2), improved levels of stakeholder engagement observed in catchments with enhanced urban rivers suggests that these restorations will become increasingly cost effective over sustained time periods if they are successful in attracting and sustaining stewardship activity thus delivering other social benefits whose value is difficult to capture. Further research and development into mechanisms and methods to demonstrate the social and environmental value of urban river restoration more effectively and to a wider audience, for example through stewardship and participatory monitoring activities, are recommended and highlighted in section 9.4.

9.2.2 Delivering urban river improvements through environmental governance models and multi-disciplinary partnership

Since the 1990s, new models of environmental governance reflecting sustainable development principles have legitimised the joint prioritisation of environmental, social and economic concerns (Meadowcroft 2000; OPDM, 2005, Young, 2009). While aspirations towards integrated environmental, water and catchment management have long histories compared to recent sustainability agendas, the documentary evidence presented in Chapter 5 demonstrates the extent to which new local to European level policies and guidance include increasingly integrated components, ranging from updated planning guidance for England and Wales: ‘Delivering Sustainable Development’(PPS1. ODPM, 2005) to the EC Water Framework Directive (WFD)

Environmental policy and other drivers

At the local level, observations reveal that the WFD-driven shift towards ecological river improvements currently holds less significance for non-river environmental practitioners, e.g. within local authorities, where the main focus is upon local Biodiversity Action Plan (BAP) targets. In this context, new regional policies such as the London Rivers Action Plan (LRAP) and Rivers and Streams Habitat Action Plans, are raising the profile of urban rivers as potential agents of environmental and social regeneration and a focus for engagement with a wide range of stakeholders. The delivery of policies at this scale with regionally-focused Environment Agency support are particularly significant for the local authorities who are often the riparian owners, with increasingly devolved responsibilities for flood risk management and green infrastructure planning for sections of river catchment. The LRAP and other regional policies that prioritise trans-borough green (and blue) infrastructure (e.g. East London Green Grid, Davidson, 2007) are evidently enabling the delivery of WFD ecological objectives with the support of multidisciplinary partners and stakeholders outside of traditional river practitioner communities as demonstrated by the main case study: the integrated restoration of the Mayes Brook and regeneration of Mayesbrook Park.

Evidence derived from the LRAP/RRC data and case study histories reported in Chapter 6 confirm that multi-disciplinary partnerships delivering urban river restoration projects across the London Thames catchment do not follow a standard model but typically include both EA and the Local Authority as core partners with involvement by a wide variety of other voluntary and private sector organisations (section 6.3.3). Involvement by private sector stakeholders was found to be mainly associated with resourcing mechanisms that were either passive: i.e. through mandatory planning agreements (e.g. Section 106) or environmental levies (e.g. landfill or aggregates tax); or active: i.e. through sponsorship and volunteering contributions (sections 6.3.4 and 7.4). The growth of interest in Corporate Social Responsibility for private sector companies with environmental business interests was also demonstrated within this research through the involvement by city insurance company Royal Sun Alliance, thus providing evidence of a successful model for further private sector engagement in future.

Integrated environmental governance challenges

The observed challenges for multi-disciplinary and multi-sector partnerships frequently reflected differences in culture and philosophy and were highlighted through the case studies by contrasting working practices and expectations. For example, evidence of inconsistencies between the different sector partners emerged strongly in relation to time factors (section 7.3.2). During the delivery stages, contrasting bureaucratic timeframes and cycles of different sectors each demanded additional attention and time allowance for the accommodation and assimilation of new information from partners, or for progressing authorisations and consents. Additional seasonal time constraints on environmental work practices, e.g. for ecological surveying or biodiversity protection activities, also impacted on work schedules and exposed differences in the expectations of environmental and non-environmental partners. Overall delays (e.g. works beginning 12 months after original prediction) reflect the lack of synchronicity between expected and actual time needed for the delivery stage to be implemented (section 7.3). The evidence within this thesis therefore supports the findings from the literature review presented in section 2.3, that the development of synergistic partnerships (Mackintosh, 1992) through the life cycle stages of integrated river restoration projects requires additional time, trust and facilitation for new connections to establish and become compatible.

The successful management of contrasting perspectives within multi-disciplinary partnership was demonstrated by the integration of partner objectives through the Mayesbrook case study planning process (Chapter 8). However, the ‘critical impulse’ described by Pickett et al, 1999 (whereby a critical approach, traditional to academic ecologists, outweighs other more constructive impulses required in an interdisciplinary research context) was demonstrated in a more general sense by some partners towards the perceived dominance of the planning process by components that were unfamiliar to their particular area of expertise. In the two main case studies, observed demands upon project managers involving liaison with large external organisations with different work cultures either within a different sector (i.e. public vs private) or at a different administrative level (i.e. regional vs continental) (section 7.2) also highlighted key bridging or facilitation roles played by individuals with an understanding of the contrasting work practices (e.g. TRRT for the Mayesbrook Park Restoration Project; Defra liaison for QUERCUS).

For the Mayes Brook case study, the perceptions of imbalances emerging through master planning processes were found to be linked partly to the technical requirements of urban river restoration such as design issues, baseline surveys or planning requirements (section 8.3.2) which appeared to give additional 'voice' to river-oriented partners. This was also emphasised by the frequent presence of visiting technical specialists e.g. EA flood engineers or WFD officers, and Thames Water Misconnections Project team members. A further contributing factor was identified as the inclusive approach to decision making, involving lengthy meetings with all partners represented in discussions relating to the full range of environmental and social aspects of the project. In this context, the different perspectives of the partners frequently revealed plural understandings of the river-oriented issues, which sometimes required additional time to translate technical aspects and build common understanding (reflecting findings reported by Raco and Dixon, 2007, section 2.3.4.2).

Observation data and documentary evidence demonstrated that additional time spent on technical river and landscaping knowledge exchange shifted the perceived balance of attention away from discussion of climate change adaptation and people engagement strategies for non-river partners. Although river-oriented discussions frequently related to social aspects of park use and design (section 8.3) the social elements were not recognised as carrying an equal emphasis by the non-river partners, reflecting perceptions of dominance by technical expertise prevalent in flood or storm water management contexts observed by Brown, 2005.

Lessons from the QUERCUS case study, demonstrate how frequent reference to three simple integrated core objectives:

- *To increase use and enjoyment of the urban river corridor*
- *To reduce crime and fear of crime*
- *To improve habitats for wildlife*

(QUERCUS Project Toolkit, LB Lewisham, 2009 and Table 7.10) supported project managers and partners in maintaining their focus on a common goal. For the Mayes Brook project, a rebalancing of integrated objectives with the support of external facilitators (via the risk assessment and monitoring strategy planning processes) succeeded in maintaining a constructive path towards the partners' common vision (section 8.4).

Specific processes observed to support the delivery of integrated and sustainable river environmental and ecosystem services outcomes included the identification of 'people engagement’ and ‘climate change adaptation’ as ‘cross cutting’ themes that transected the aquatic and terrestrial monitoring themes through the monitoring strategy development process. In this way, the Mayesbrook case study demonstrated a novel approach to integrating social and environmental post-project monitoring objectives as part of a trial of the previously untested PRAGMO methodology (RRC, 2011, described in section 4.4).

The integration of social and environmental outcomes within the Mayesbrook monitoring strategy also revealed an opportunity to formally link post-project monitoring objectives with opportunities for public engagement and long term stewardship of the aquatic and terrestrial environments. Similar approaches to participatory monitoring demonstrated by the British Trust for Ornithology (Greenwood, 2003) and a recent increase in citizen science recording activities e.g. OPAL (www.opalexplorenature.org/) have shown an enthusiastic uptake by the public and, in the case of bird monitoring, significant policy influence (Parr et al. 2003). The combination of social and environmental objectives combined with attractive engagement opportunities thus presents a potentially powerful approach to sustainable integrative urban river planning and management.

9.2.3 Integrated assessment tools for knowledge exchange, decision making and delivering environmental policy objectives

Over the last decade, WFD objectives and the River Basin Management Plans (RBMP) have become increasingly important drivers to London river management alongside BAP and flood risk management priorities (sections 5.3 and 5.4). However, effectiveness of the integrated RBMP approach has yet to be demonstrated in terms of (i) the ecological objectives, (ii) effective stakeholder delivery of non-statutory measures and stewardship activities.

Evidence presented in this thesis indicates a preference by multi-disciplinary partners involved in urban river restoration for clear environmental objectives communicated without excessive technical detail (section 8.3.2). Observation and interview data confirm the value of easily interpreted decision making tools that are able to synthesise and present sound scientific analyses with clear and engaging non-technical visual outputs such as map-based spatial illustrations and simple matrices showing a range of options or outcomes e.g. the URS Matrix (section 8.4.2). Overall findings indicate that to be most effective, knowledge exchange tools and delivery need to be (i) flexible and

(ii) balanced in line with audience interests, and communicated through (iii) easily interpreted language and (iv) visuals, to accommodate and build upon the different expectations and perceptions of partners, sponsors and stakeholders (section 8.4).

To facilitate multi-disciplinary partnership decision making, river project managers need to provide information on (i) the existing ecological condition of water bodies, (ii) the relevant options for restoring and improving ecological condition to meet legislative requirements and (iii) short and long term views of potential wider benefits to local communities and ecosystems compared to (iv) the estimated costs of capital works and (v) ongoing socio-environmentally-oriented river assessment and management. The two assessment methods selected for this thesis demonstrate two very different kinds of interdisciplinary approach with the potential to communicate the outcomes of urban river restoration to a diverse range of stakeholders.

Integrated bio-physical assessment

The evidence presented in Chapter 4 demonstrates how detailed bio-physical information captured by the URS allows differences in habitat condition and engineering impacts to be compared at the reach and catchment scale as demonstrated by the comparisons of pre- and post-restoration condition of paired reaches on the rivers Brent and Ravensbourne (section 4.4) and across the Mayesbrook catchment (section 4.5). The URS data and outputs have the potential to inform scientists and practitioners of habitat condition at different levels, ranging from more detailed analyses of individual indices representing specific habitat features, such as counts of tree features or different (in-channel) habitat types (section 4.2.2), to ‘higher level’ catchment-scale interpretation of reach characteristics via the URS matrix (section 4.5.4). The integrated overview of engineering impacts upon habitat across the catchment provided by URS outputs can help managers to identify reaches with the greatest potential for bio-physical and ecological improvement. At the reach scale, the URS method can provide baseline (pre-restoration) data or post-project appraisal and monitoring data to build knowledge about responses to restoration works such as changes in the frequency or overall diversity of habitat types (sections 4.4 and 4.5).

Further opportunities exist to review URS outputs in conjunction with hydrological data, such as the frequency and timing of high stage or channel modifying flows. In this context, URS data recorded before and after flood events have the potential to provide evidence of associated physical changes such as the creation or re-location of depositional bars or erosional features such as vertical scoured or undercut banks.

By demonstrating a range of potential outcomes, the URS matrix also provides a means to communicate observed (and potential) differences in river channel response to restoration works, highlighted by Clark (2002) as a key area of uncertainty for river managers. The importance of investigating different types of channel response, also noted by Walsh et al. (2005) in order to manage such uncertainties supports the argument for greater investment in monitoring and post-project appraisal, to provide evidence outcomes which can also feed back into long term sustainability and adaptive management strategies. Furthermore, communicating a range of potential outcomes to restoration works also helps to manage stakeholder expectations of channel responses over time.

Integrated socio-environmental assessment

By contrast, the ESA draws upon broader environmental economic analyses involving direct/indirect market or contingent valuation methods (de Groot et al. 2002), to provide a more socially-oriented assessment of the changes in the value of human benefits gained from river ecosystem services associated with intervention works (section 4.7 and Appendix D). Despite the limits summarised in section 9.2.1, as an assessment tool the ESA is able to provide a tentative estimate of reach or catchment scale benefits in economic terms thus informing river finance managers and ‘speaking to’ a wider range of potential sponsors of the estimated cost effectiveness of environmental restoration projects in line with partner interests and objectives.

The observation and interview data gathered during this research project indicate the importance of having a range of different assessment types and levels to engage with different types of stakeholder or practitioner, reflecting findings by Reed (2008) and Orr et al. (2007) relating to stakeholder involvement in integrated river basin planning in England and Wales. In order to engage with a wide audience of stakeholders at a variety of levels, river scientists and practitioners need to take a flexible approach to information sharing and have the ability to move between generic concepts and case specific details. More explicitly, in all cases, the use of visual tools such as multi-scale maps was observed as an essential tool for knowledge exchange between multi-disciplinary partners. Communication benefits can also be gained through the use of Geographical Information Systems and interactive map technologies. Although such spatial visual tools may appear to be an obvious addition, it was clear from observations that there were often occasions when their use was limited. Where these were used effectively they were found to significantly enhance knowledge exchange and interdisciplinary or inter-sector communications. Recommendations for further research and development of flexible knowledge exchange methods and tools to facilitate stakeholder engagement for sustainable urban river management are highlighted in section 9.3 and 9.4.

9.2.4 Supporting practitioners through environmental information systems and knowledge exchange processes

External environmental information exchange

The evidence presented in Chapter 6 demonstrates the wealth of environmental information that is becoming increasingly available through online media sources (e.g. LRAP, GiGL, URS web sites, section 6.2). Most publically accessible internet databases enable a spatial and qualitative visualisation of data, ranging from species distributions (National Biodiversity Network) to river and sea levels (EA What's in Your Backyard) using interactive maps with geo-referenced data source points. Online databases can be interrogated to varying degrees either spatially via the map or using various search terms. While some sensitive data (e.g. relating to the location of a protected species) are restricted, requiring request procedures or password entry, others may be downloaded in a variety of formats ranging from pdf summaries to MS Excel or ArcGIS file formats.

The functionality of most environmental information systems at present remains focused on laboratory or desk–based interactions using personal or laptop computers. As wireless local area networks (WLAN) or WiFi becomes increasingly accessible within the urban environment allowing remote access to the internet and Global Positioning Systems (GPS), there is a clear opportunity for the development of new types of software applications (or 'apps') either as directories of information or field survey input interfaces, which can be accessed via'smart' mobile telephones or tablet computers and used in the field. Examples of these new technologies have already been specifically developed for outdoor settings by a few organisations e.g. the Museum of London, Explore-Online 'Street Museum' (www.museumoflondon.org.uk/Explore-online/Apps/) clearly indicating the potential for a wide range of environmental surveying applications e.g. identifying, locating and recording specific species of interest e.g. non-native invasive species.

Internal environmental information exchange

The evidence gathered through observation and interviews, indicates that multi-disciplinary partnership models involved in urban river restoration employ a range of different formal (e.g. steering group meetings and circulation of minutes) and informal (e.g. one-to-one briefings) approaches to internal information sharing. The combination of mechanisms and practices involved generally reflect the mixture of different work cultures and available technologies. The need for effective knowledge exchange processes was observed throughout the project planning and delivery stages of the main case study (e.g. for gathering and preparing the baseline environmental and social data for the masterplan and public consultation; gathering information for the planning application and responding to planning responses; preparation of the post-restoration monitoring strategy, section 8.3).

Observed challenges to partnership knowledge exchange were highlighted by changes within steering group memberships of the case studies. The size and changing membership of multi-disciplinary partnerships were observed to affect information gathering and sharing at various stages of the process. The most obvious impact of this was upon time taken to exchange information and the resulting delays to the project planning process. Mechanisms for information sharing appeared to generally be ad hoc, however, observations indicated an opportunity to establish a remote database (making use of remote storage or ‘cloud’ technology) with secure access to all partners which would provide a centralised database for project information and facilitate the induction of new partners or when unavoidable changes in personnel occur. Although, an attempt by the main case study partnership to introduce such a feature towards the end of the observation period was not effective, interview data confirmed that remote access data sharing technologies are currently being incorporated into stakeholder business practices. It is expected that such features will grow in importance and accessibility to meet partnership information management demands in future integrated projects.

Throughout the Mayesbrook case study, use of matrices was also observed to be a valuable tool for communicating complex information and facilitating interdisciplinary processes. For example, during the monitoring strategy development stages (section 8.3) and for communicating habitat:engineering interactions via the URS matrix (sections 4.4 and 4.5). Further discussion of matrix tools and devices is presented in section 9.3.

9.3 Research contributions to interdisciplinary approaches to assessing and managing urban rivers

The research presented within this thesis is not based on the assumption that an interdisciplinary approach is inherently better than single disciplinary practice. Indeed, the evidence emphasises the fundamental value of disciplinary knowledge as an essential input to interdisciplinary processes. However, in order to address the challenges of sustainable development, the results point to a continuing need for single disciplinary practitioners to prioritise the development and maintenance of dissemination, access and facilitation mechanisms for interdisciplinary processes and knowledge exchange, in order to help to bring more research knowledge into practice, reflecting findings by Rogers (2006).

Recommendations for interdisciplinary research practice made by Evans and Marvin, 2006; Evans and Randal, 2008; Pickett et al. 1999; Campbell, 2005 (highlighted in Chapter 1, Table 1.2, Box 9.1) were found to be highly relevant for urban river restoration planning and management in relation to expectation management, time allowance and the development of new conceptual frameworks for disciplinary integration. A series of contributions provided by this research project to knowledge of urban river assessment, planning and management are described within this section.

Box 9.1 Recommendations for interdisciplinary research, identified by Evans and Marvin, 2006; Evans and Randal, 2008; Pickett et al. 1999; Campbell, 2005.

- Reshape conventional disciplinary boundaries through cross-cutting collaborations
- Attract researchers across disciplinary boundaries through a new style of coordinated management between research funding bodies
- Balance numbers of environmental and social scientists
- Use common language and innovative engagement strategies, allow the use of polyvocal methods
- Develop conceptual frameworks for interdisciplinary approaches, replacing hierarchy with adjacency
- Allow longer time to build common understanding and greater attention by authors and reviewers
- View social sciences in terms of systems approach to encompass: different scales, types of change and classifications
- Manage expectations
- Disseminate results to end users, ensuring that policy needs are met.

New knowledge regarding the bio-physical state of London rivers

With respect to the integrated assessment of heavily modified rivers, the Urban River Survey (URS) results have provided evidence of the bio-physical character of London rivers (in terms of bed/bank materials, physical habitat and vegetation structure), revealing a broad range of habitat condition, (from no habitat to diverse morphology and habitat patches) in association with different levels and types of channel engineering. New knowledge generated by this investigation will provide a valuable baseline and starting point for future research to build upon. The development of the URS as a user-friendly monitoring tool for practitioners will encourage the collection of further data and indicates potential for further research and development of this method.

Demonstrating the potential of the Urban River Survey to meet policy goals

The potential of the URS to serve as a tool to support the delivery of the WFD by assessing hydromorphological measures contributing to (WFD defined) ecological potential is also demonstrated by the wide variety of ordinal and numeric data gathered during the survey including semi-quantitative scores for physical properties such as bed/bank materials, ranked using the Wentworth or Phi scale (after Latulippe et al, 2001); and counts and percentages of key habitat features e.g. (un)vegetated bars. The integrated approach of the URS in gathering data defined by the engineering type of each reach provides a powerful opportunity to build knowledge of the nature of urban reaches which are highly fragmented by their engineering.

Further potential exists to extend the scope of the URS method to include semi-quantitative measures of socio-economic indicators such as land use data, as described in section 9.4. The development of such methods would also complement ‘reconciliation ecology’ approaches which seek to redesign anthropogenic habitats to be compatible with a wide array of species (Rosenzweig, 2003), through more focused investigations of urban river habitat diversity and ecological functioning in relation to anthropogenic impacts. Furthermore, the development of measures of habitat dynamism within urban river systems such as indicators of sediment deposition or bank erosion, would help practitioners to understand and manage in-channel habitat-generating processes within heavily modified channels and at the reach and catchment scales.

Evidence of integrated governance approaches to urban river restoration

As opportunities for interdisciplinary interactions increase through the pursuit of sustainable development and partnership working, the evidence within this thesis suggests that a greater focus on facilitation mechanisms and identification of ‘cross-cutting themes’, would make knowledge exchange and decision making processes more inclusive, thereby building the participatory bridges, ladders and wheels highlighted by Pickett et al. (1999) and Clark (2002); and managing uncertainties more robustly. The following section proposes one such mechanism with potential to catalyse interdisciplinary processes and to build awareness of interdisciplinary connectivity.

Under current environmental management paradigms (section 2.3) new emphases on sustainable development, the ‘ecosystem approach’, and partnership delivery are driving the opportunities for interdisciplinary practice within urban river restoration. Together these drivers set high expectations upon interdisciplinary approaches to produce robust outcomes and mutually agreeable solutions, whilst demonstrating their success to stakeholders from a wide variety of socio-economic and cultural backgrounds, with a correspondingly wide set of expectations and attitudes towards urban river environments.

New knowledge of processes influencing objective integration in partnership planning

The case studies reviewed in Chapter 8 each represented opportunities where interdisciplinary processes and practice might develop. However, in both cases integration between disciplines appeared to be limited by contrasting expectations, disciplinary (i.e. methodological, conceptual or institutional) rigidity, and perceived obstacles, which limited interdisciplinary processes. For example, the perceptions of the non-river practitioners of dominance by river restoration engineering issues were further compounded by a lack of social stakeholder representation and discussion of socially-oriented issues within steering group meetings (section 8.3.2). However, as social elements were integral to many of the river restoration and park regeneration issues, the reviewed projects inevitably swayed between multi-and interdisciplinary interactions, with integration occurring more by opportunity or chance rather than by design.

While the quest for integrated sustainable development permeates the literature and recent policy, the reality of delivering beneficial sustainable outcomes to all partners and stakeholders does not necessarily reflect the characteristic diversity of urban socio-environmental systems and contrasting stakeholder priorities (Clark, 2002). Again this highlights the need for conceptual models for interdisciplinary practices which enable the identification and integration of the complementary components of systems; seeking common grounds on which to build trust and *proportionate* agreement within non-rigid or ‘fuzzy’ frameworks which allow the accommodation of contrasting views and constraints. Such a model would support the demands of participatory decision making in the context of sustainable adaptive management as highlighted by Clark (2002).

The evidence presented within this thesis demonstrates how contrasting elements (e.g. natural and artificial physical indicators or disciplinary views) can be combined through the use of integrative tools i.e. mechanisms, methods or themes. One example is the use of principal component analysis (PCA) to reduce the number of multiple habitat and engineering variables of urban rivers to their principal (and most information rich) components, interpreted through the URS matrix (section 3.2.2).

By the same conceptual reasoning, an effective reduction of variability between multi-disciplinary partner objectives was also observed to operate through similarly integrative mechanisms i.e. the monitoring strategy and risk analysis frameworks. In this case, objective complexity was reduced via the identification of core common elements. In practice, during the monitoring strategy development process, the core objectives of each partner were identified, grouped under themes and combined. In a similar way, the risk analysis workshop also drew upon core concerns and risks from across the group; these were prioritised by the group as individuals, reordered by consensus and redistributed for management or mitigation. The URS, monitoring strategy development and risk analysis processes each demonstrate integrative interdisciplinary approaches whereby contrasting single discipline elements (habitat, engineering, social, environmental) were recognised, prioritised and recombined, linking or emphasising the most information rich / multi-objective fulfilling / risk-generating components.

The power of matrix frameworks to catalyse interdisciplinary processes by illustrating and enabling identification of associations (as conceptual or practical alignments) between different components of or entities involved in urban river planning is demonstrated by the hierarchical matrix in Table 9.2. This table was created by the author as a research device to explore the potential of integrative conceptual frameworks. It demonstrates an experimental approach to generating an integrated overview of the spatial and administrative hierarchies that co-exist within society and the natural environment. The first row identifies four environmentally-oriented and four socially-oriented fields with relevance to river environments and their management. In this example, the first environmental field: ‘River – spatial scale’ describes the hierarchical spatial distribution of river system components from river basin down to habitat patch (this could be extended to the micro-scale according to purpose). The first

Table 9.2 Matrix of parallel hierarchical structures for environmental and social components

Environmental: River ***Spatial scale*** **(BLUE)**	**Environmental: Urban** ***Interactive opportunities*** **(BLUE/GREEN)**	**Environmental & Water** ***Policy delivery / Management context*** **(BLUE/GREEN)**	**Environmental: River** ***Research focus e.g. URS*** **(BLUE)**	**Social: Cross sector** ***Institutional Spatial scale***	**Social: Cross sector** ***Organisational context***	**Social: Public sector** ***Policy delivery / Management context***	**Social: Cross sector** ***Research focus: e.g. case study projects/partners***
River Basin District		National: Regulations / strategic plan	Thames catchment	National	Head office	National government / QUANGO	WFD River Basin Management Plans
Whole river systems / major catchment	Green grid / Blue ribbon infrastructure	Regional: management plans	Greater London Thames basin	Regional	Regional office	Regional agency / QUANGO	**Priority parks projects;** GLA; EA Thames Region/Area; NE – London; TRRT; LWT
Tributary or Sub-catchment / WFD surface water body			Tributaries: Ravensbourne; Brent; Wandle; Mayes brook; Lee etc	Sub-region	Area or District office	Local authorities /	**Wandle Trail;** London Boroughs; Wandle Trust; Brent Catchment Partnership; QWAG
Segment to Reach	Conservation zone / River corridor reserve to Park	Local delivery: Neighbourhood Engagement / consultation	Restoration reaches / URS survey reaches	Local: Neighbourhood / Park	Local office	Community: organisations / groups (e.g. broad interest)	**Mayesbrook Park project;** QUERCUS; Park Friends groups e.g. LFPUG;
Habitat	'Honey pot' / 'destination' feature	Stakeholder engagement / consultation	URS habitat features; spot checks	Local: Site	Local centre / Event based	Community: sub-groups (e.g. special interest)	**Mayes Brook restoration;** Park Ranger post

social field: ‘Cross sector – Institutional spatial scale’ describes the corresponding administrative unit relevant to the equivalent environmental unit. The other fields represent an investigation of the role and relevance of a range of environmental management tools to the nested spatial scales represented within river systems. As such it provided an effective means of building knowledge of the mechanisms of river management within Greater London. For example, the framework highlights the opportunities for supporting local scale stewardship activities by community groups delivered by a dedicated park ranger; also the key roles for Local Authorities and the Regional Authorities in liaising with River Trusts and linking catchment scale activities across social administrative boundaries.

The evidence presented within this thesis suggests that, as different approaches to understanding the conjunction of environmental and social mechanisms and objectives within urban river restoration projects develop, it is vital that more inclusive frameworks emerge to assist practitioners bring together varied disciplinary knowledge and interpretations, and engage in processes that catalyse and nurture both inter- and trans-disciplinary opportunities.

9.4 Recommendations for further research

Based on the evidence of London river assessments and management practices, this research project has identified some potential ways forward for interdisciplinary and sustainable development of urban river management in relation to:

a) the integrated assessment and communication of improvements in ecological condition and ecosystem services for urban rivers; and

b) interdisciplinary approaches to urban river management (in relation to issues identified in Chapter 1) focused upon:

   - sustainable development (in context of austerity)
   - cross sector partnership knowledge exchange

This final section provides a series of recommendations based upon the main research findings. These highlight potential areas of opportunity for the development of: the URS assessment method to provide more sensitive measures of (i) vegetation habitat quality; (ii) characteristics of land use (as a diffuse pollution and socio-economic indicator); and (iii) the dynamic qualities of habitat features. Also, potential ways to develop the ecosystem services assessment (ESA) method are considered in order to devise (iv) novel but financially compatible credit mechanisms to extend valuation methods to include more socially-oriented cultural and aesthetic ecosystem services e.g. relating to quality of life and mental wellbeing; (v) integrative matrix methods as flexible tools to act as catalysts for interdisciplinary associations and processes; and (vi) further socially-oriented research into the mechanisms linking environmental science and practice.

i. Vegetation indices

A minor revision of the URS riparian vegetation indices is recommended to increase sensitivity to riparian vegetation diversity in semi-aquatic transitional habitat zones. Minor enhancements of the riparian vegetation data gathered as bank face / top structural complexity could also provide useful information on the habitat of semi-aquatic species, and further indication of vegetation height would be beneficial. For example, if vegetation structure is recorded as ‘uniform’, differentiating between tall grasses and creeping herbs would provide additional ecological information about habitat functionality (i.e. as protective cover). This would enable the identification of species-specific vegetation preferences, e.g. tall herbs on bank face/top for water voles.

Additional riparian vegetation indices would also allow more detailed queries to be performed in relation to morphological and functional units (e.g. bank profiles and protection levels). An index of riparian vegetation cover could be used to identify the characteristics of banks with low vegetation density and assess the level of vulnerability to colonisation by nuisance riparian species, such as Himalayan balsam (*Impatiens glandulifera*) or Giant Hogweed (*Heracleum_mantegazzianum*). These data could also be enhanced by collecting more detailed information for individual nuisance species either as cumulative counts or as percentage cover at spot checks. These additional data would also allow further investigation into the generation of a specific nuisance species index.

ii. Land use index

Opportunities for more detailed analysis of river corridor diffuse pollution sources and socio-economic components exist through URS land use data. The development of a land use index would introduce opportunities to link urban river habitat condition with diffuse pollution sources as well as socio-economic indicators of human riparian communities. These additional local human riparian components could be complemented by external data sources and broader socio-economic analyses of land use, e.g. via the Greenspace information for Greater London (GiGL) database. The development of a land use index based upon the 50m corridor could also contribute to analyses of ecosystem services provision to nearby communities.

iii. Habitat dynamism index

Reflecting a gap highlighted by the literature review (section 2.2.5) for measures of channel dynamism as an indicator of stream energy function and in-channel processes, there is an opportunity also to develop a specific index relating to eroding and depositional features and other signs of habitat turnover. Suitable features recorded within the URS might include unvegetated mid and side channel bars, vertical and undercut banks, scour pools and large woody debris. As the URS records a one-off measure of channel width and depth for each survey reach, these values could also be used to investigate relationships between habitat dynamism and channel dimensions within different river catchments.

Despite the increased risks of flooding within urbanised river catchments, the hydrological data available for analysis are relatively limited. Where hydrological data do exist, further opportunities to investigate relationships between a habitat dynamism index and hydrological regimes, and especially high flow events, could shed further light on in-channel morphological responses over time. A measure of habitat dynamism that could indicate for example, the recruitment and mobilisation of sediment through a surveyed stretch, would be of particular interest in relation to measuring the outcomes of river restoration: to demonstrate changes in morphological functioning, habitat maintenance and turnover. More detailed data describing habitat dynamism could also be useful in interpreting the temporal trajectories of individual surveyed stretches (described in section 9.2.1) in conjunction with the URS PC gradients and Matrix tool.

From a river management perspective, riparian land owners and restoration practitioners could also benefit from knowledge relating to potential channel migration in the absence of hard engineering and bank protection.

iv. Novel credit systems for environmental valuation

An extension of environmental economics and monetary valuation systems is urgently needed to include novel ecological credit strategies and account for the ‘hard to monetise’ elements of aesthetic and cultural ecosystem services. It is vital that alternative and compatible methods of valuing social and environmental resources (i.e. social and natural ‘capital’) are researched and developed, especially in the context of global economic uncertainties (TEEB, 2010a, Cornell, 2011, Everard et al, 2011). As an initial stage of development, attempts to quantify using alternative mechanisms (e.g. as time / people-hours, numbers of participants, sorted by age or other social measure or some other familiar metric) would provide a preliminary baseline.

Although some alternatives to conventional financial systems (e.g. Local Exchange Trading Systems or LETS) have not been widely accepted, others (e.g. Microfinance) have been proven as successful alternative models. If an alternative system of valuation could also be developed for ESA, it would represent a significant development, compatible with and potentially able to contribute to the TEEB tiered approach of firstly recognising and secondly demonstrating value (TEEB, 2010a).

v. Flexible interdisciplinary frameworks

Evidence from this thesis demonstrates the essential role of flexible frameworks and adequate time allowance for interdisciplinary processes to emerge and develop, i.e. to catalyse recognition of common themes, create inclusive spaces and accommodate discrepancies. Research recommendations therefore include further testing of the use of 2-d integrative models such as the URS matrix (sections 4.4.2 and 4.5.4) and PRAGMO framework (section 8.3), whilst allowing for broader interdisciplinary working time frames compared to standard disciplinary approaches.

In summary, to enhance urban river planning and management strategies and improve spatial and temporal coordination, the facilitation and integration of catchment scale conservation and environmental management requires (i) a greater allowance for time within interdisciplinary and inter-sector integrative processes, coupled with (ii) greater flexibility in financial administration and funding conditions, and also (iii) the spatial integration of sub-catchment scale administrative regions and the identification of common cross-borough interests. To facilitate the use of flexible approaches, the allocation of a dedicated project manager for complex urban social-environmental integrated projects is also highly recommended. The complex demands of planning and managing ‘wicked’ urban river project sustainable delivery, appraisal and legacy require additional time and attention on multiple levels.

vi. Social science of environmental practice

Future stewardship of urban rivers will depend upon the involvement of local people and sensitive management of stakeholder engagement by river practitioners. Changes in urban river restoration practice over time demonstrated by this thesis indicate a trend towards a greater focus on community demand and social objectives (sections 6.3 and

8.3). Further socially-oriented investigations of environmental practice, both in terms of management and stakeholder participation, are recommended in order that objective integration through blue and green infrastructure regeneration and urban river stewardship might become a common mindset for catchment managers and communities. Research into the success of engagement practices achieved by London-based organisations such as the Wandle Trust, the Quaggy Waterways Action Group, and Thames 21; and other mechanisms to enhance the connectivity of communities (e.g. via 'adopt-a-river' initiatives (www.ukrivers.net/wiki/doku.php?id=adopt_a_river) and the Three Rivers clean up (www.qwag.org.uk/3riverscleanup/)) could inform best practice for enhancing and extending stakeholder participation through combined social and environmentally-oriented activities (Figure 9.1) These types of local engagement approaches have the potential to capture the interest of future generations of stakeholders and are relevant to urbanised river catchments far beyond Greater London.

Figure 9.1 Three Rivers Clean Up event involving local school children on the new river Ravensbourne channel at Ladywell Fields, June 2010 (http://schoolsintheparks.wordpress.com/2010/07/05/june-2010-the-3-rivers-clean-up-and-sceince-in-greenwich-park/)

Where new restorations are planned, the initiation of stakeholder participation groups at the earliest opportunity, including specific river and/or riparian wildlife and recreational interest groups, can pre-empt later expressions of discontent relating to river restoration works. Although local expressions of concern may represent a negative reaction to proposed river works, they may also provide starting points for constructive engagement. Therefore research into mechanisms for channelling negative perceptions into positive advocacy for environmental improvement might enable such approaches to be welcomed as demonstration of interest rather than antagonism or apathy. Where the perceived concerns of local residents regarding urban river restoration can be pre-empted and addressed at the earliest opportunity through liaison with key local groups, an open dialogue can facilitate the exchange of local and expert knowledge and ease progression towards mutually understood objectives (EA Conservation Officer, personal comments, 2011).

Harnessing human power for sustainable urban river management through local stewardship and monitoring activities represents an invaluable investment that is hard to monetise. In the long term, an investment in socially-oriented research of environmental practice could represent a highly cost effective approach to the sustainable improvement and maintenance of urban river ecological and community wellbeing and resilience to future environmental change.

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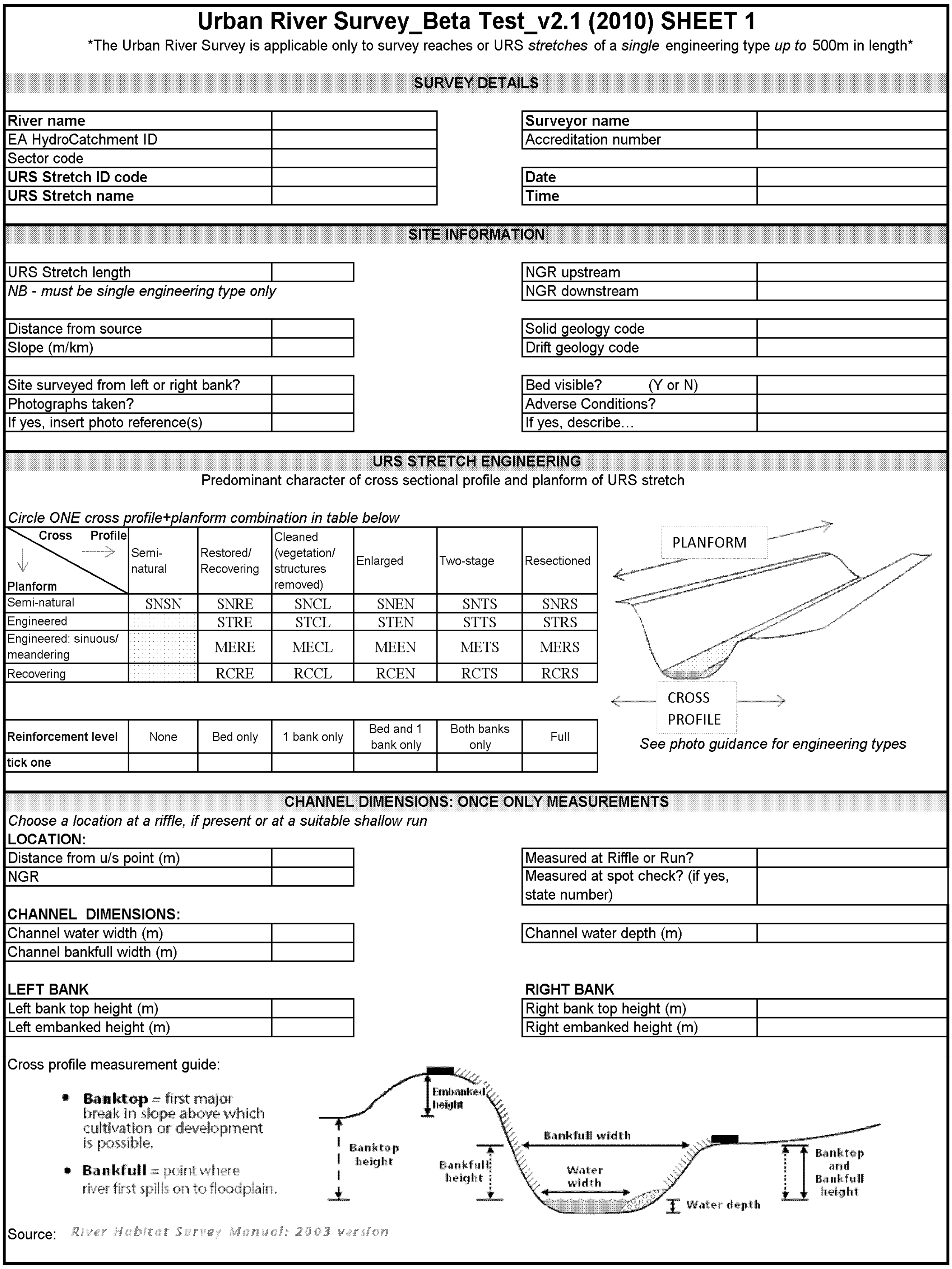
Appendix A: URS Survey Forms

Copy of the of URS Beta Test (v2.1) forms developed during PhD research 2009-10



Urban River Survey_Beta Test_v2.1 (2010) SHEET 1

*The Urban River Survey is applicable only to survey reaches or URS *stretches* of a *single* engineering type *up to* 500m in length*

SURVEY DETAILS

River name		**Surveyor name**	
EA HydroCatchment ID		Accreditation number	
Sector code			
URS Stretch ID code		**Date**	
URS Stretch name		**Time**	

SITE INFORMATION

URS Stretch length		NGR upstream	
NB - must be single engineering type only		NGR downstream	
Distance from source		Solid geology code	
Slope (m/km)		Drift geology code	
Site surveyed from left or right bank?		Bed visible? (Y or N)	
Photographs taken?		Adverse Conditions?	
If yes, insert photo reference(s)		If yes, describe…	

URS STRETCH ENGINEERING

Predominant character of cross sectional profile and planform of URS stretch

Circle ONE cross profile+planform combination in table below

Cross Profile → ↓ Planform	Semi-natural	Restored/ Recovering	Cleaned (vegetation/ structures removed)	Enlarged	Two-stage	Resectioned
Semi-natural	SNSN	SNRE	SNCL	SNEN	SNTS	SNRS
Engineered		STRE	STCL	STEN	STTS	STRS
Engineered: sinuous/ meandering		MERE	MECL	MEEN	METS	MERS
Recovering		RCRE	RCCL	RCEN	RCTS	RCRS

Reinforcement level	None	Bed only	1 bank only	Bed and 1 bank only	Both banks only	Full
tick one						

See photo guidance for engineering types

CHANNEL DIMENSIONS: ONCE ONLY MEASUREMENTS

Choose a location at a riffle, if present or at a suitable shallow run

LOCATION:

Distance from u/s point (m)		Measured at Riffle or Run?	
NGR		Measured at spot check? (if yes, state number)	

CHANNEL DIMENSIONS:

Channel water width (m)		Channel water depth (m)	
Channel bankfull width (m)			

LEFT BANK		**RIGHT BANK**	
Left bank top height (m)		Right bank top height (m)	
Left embanked height (m)		Right embanked height (m)	

Cross profile measurement guide:

- **Banktop** = first major break in slope above which cultivation or development is possible.
- **Bankfull** = point where river first spills on to floodplain.

Source: *River Habitat Survey Manual: 2003 version*

URBAN RIVER SURVEY_Beta Test_2.1 (2010) SHEET 2

SPOT-CHECK MEASUREMENTS

*Spot-check data must be gathered at **ten** spot checks located at equal intervals along the URS stretch (irrespective of reach length)*

Survey commenced from: Downstream end ☐ Upstream end ☐

*Record predominant parameter using codes provided; if channel is **two-stage:** split box to record features for both stages*

PARAMETER	1 GPS	2	3	4	5	6 GPS	7	8	9	10	SW
PHYSICAL ATTRIBUTES (1m transect across channel)											
LEFT BANK											
Left bank material AR, BE, BO, CO, GS, CE, EA, CL, NV											
Left bank protection CC, CB, BR. BW. SP, WP, RR, GA, RE, WS, WO, NO											
Left marginal & bank features NV, NO, EC, SC, PB, VP, SB, VS, NB											
RIVER CHANNEL											
Channel substrate AR, BE, BO, CO, GP, PE, SA, SI, CL, NV											
Flow Type BW, UW, CH, FF, CF, UP, RP, SM, NP, DR											
Channel features NV, NO, EB, RO, VR, MB, VB, MI, TR											
RIGHT BANK											
Right bank material AR, BE, BO, CO, GS, CE, EA, CL, NV											
Right bank protection CC, CB, BR. BW. SP, WP, RR, GA, RE, WS, WO, NO											
Right marginal & bank features NV, NO, EC, SC, PB, VP, SB, VS, NB											
BANKTOP LAND USE & VEGETATION STRUCTURE (10m transect)											
LAND USE CODES: Re, Cm, In, Ic, Tr, Sw, Ld, Dr, Cr, Pa, Or, Fe, Co, Dd, Ow, He, Sc, Op, Rc, Ce, La, Rv, Ca, Qu, Tb											
LEFT bank landuse (within 5m)											
Left bank top structure (within 1m) B, U, S, C											
Left bank face structure B, U, S, C											
RIGHT bank face structure B, U, S, C											
Right bank top structure (within 1m) B, U, S, C											
Right bank landuse (within 5m)											

CHANNEL VEGETATION (10m transect)

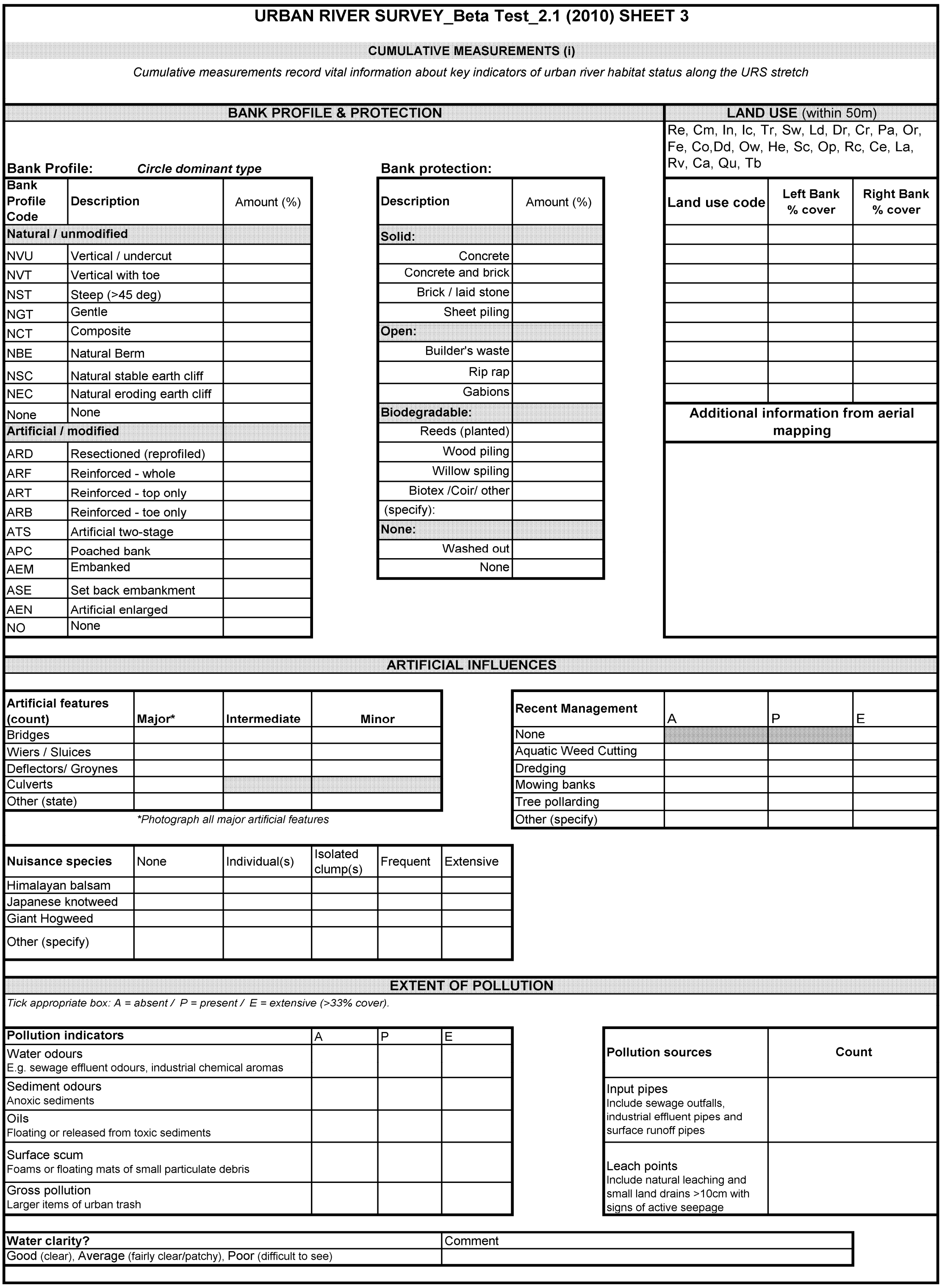
Record vegetation present in transect as a percentage of macrophyte zone

Vegetation type	1	2	3	4	5	6	7	8	9	10	SW*
None											
Liverworts/mosses/lichens											
Emergent broad-leaved herbs											
Emergent reeds/ linear-leaved/ horsetails											
Floating leaved (rooted)											
Free-floating											
Amphibious											
Submerged broad-leaved											
Submerged linear-leaved											
Submerged fine-leaved											
Filamentous algae											
Macrophyte Species (specify):											

***SW** - Record type and estimate % cover of other macrophyte types present in stretch but not at spot checks*

Channel choked with macrophytes? (if YES, identify species or type) ☐

Additional notes:



URBAN RIVER SURVEY_Beta Test_2.1 (2010) SHEET 3

CUMULATIVE MEASUREMENTS (i)

Cumulative measurements record vital information about key indicators of urban river habitat status along the URS stretch

BANK PROFILE & PROTECTION

Bank Profile: *Circle dominant type*

Bank Profile Code	Description	Amount (%)
Natural / unmodified		
NVU	Vertical / undercut	
NVT	Vertical with toe	
NST	Steep (>45 deg)	
NGT	Gentle	
NCT	Composite	
NBE	Natural Berm	
NSC	Natural stable earth cliff	
NEC	Natural eroding earth cliff	
None	None	
Artificial / modified		
ARD	Resectioned (reprofiled)	
ARF	Reinforced - whole	
ART	Reinforced - top only	
ARB	Reinforced - toe only	
ATS	Artificial two-stage	
APC	Poached bank	
AEM	Embanked	
ASE	Set back embankment	
AEN	Artificial enlarged	
NO	None	

Bank protection:

Description	Amount (%)
Solid:	
Concrete	
Concrete and brick	
Brick / laid stone	
Sheet piling	
Open:	
Builder's waste	
Rip rap	
Gabions	
Biodegradable:	
Reeds (planted)	
Wood piling	
Willow spiling	
Biotex /Coir/ other	
(specify):	
None:	
Washed out	
None	

LAND USE (within 50m)

Re, Cm, In, Ic, Tr, Sw, Ld, Dr, Cr, Pa, Or, Fe, Co,Dd, Ow, He, Sc, Op, Rc, Ce, La, Rv, Ca, Qu, Tb

Land use code	Left Bank % cover	Right Bank % cover

Additional information from aerial mapping

ARTIFICIAL INFLUENCES

Artificial features (count)	Major*	Intermediate	Minor
Bridges			
Wiers / Sluices			
Deflectors/ Groynes			
Culverts			
Other (state)			

**Photograph all major artificial features*

Recent Management	A	P	E
None			
Aquatic Weed Cutting			
Dredging			
Mowing banks			
Tree pollarding			
Other (specify)			

Nuisance species	None	Individual(s)	Isolated clump(s)	Frequent	Extensive
Himalayan balsam					
Japanese knotweed					
Giant Hogweed					
Other (specify)					

EXTENT OF POLLUTION

Tick appropriate box: A = absent / P = present / E = extensive (>33% cover).

Pollution indicators	A	P	E
Water odours E.g. sewage effluent odours, industrial chemical aromas			
Sediment odours Anoxic sediments			
Oils Floating or released from toxic sediments			
Surface scum Foams or floating mats of small particulate debris			
Gross pollution Larger items of urban trash			

Pollution sources	Count
Input pipes Include sewage outfalls, industrial effluent pipes and surface runoff pipes	
Leach points Include natural leaching and small land drains >10cm with signs of active seepage	

Water clarity?	Comment
Good (clear), Average (fairly clear/patchy), Poor (difficult to see)	

URBAN RIVER SURVEY_Beta Test_2.1 (2010) SHEET 4

CUMULATIVE MEASUREMENTS (ii)

Cumulative measurements record vital information about key indicators of urban river habitat status along the survey reach

HABITAT FEATURES

Record as COUNT

Habitat feature code (C)		**Count**	Natural/ Artificial/ Restored
BE	Bedrock		
RO	Rock/boulder		
WF	Waterfall		
RI	Riffle		
PO	Pool		
BW	Marginal Backwater [1]		
SL	Discrete silt deposits		
SN	Discrete sand deposits		
IS	Island		
MB	Mid-channel bar (Unvegetated)		
VM	Vegetated mid-channel bar		
PB	Point bar (Unvegetated)		
VP	Vegetated point bar		
SB	Side bar (Unvegetated)		
VS	Vegetated side bar		
WD	Woody debris [2]		
WJ	Wood Jam (blocking channel)		

Record as PERCENTAGE

Habitat feature code (P)		**Percent (%)**	Natural/ Artificial/ Restored
CC	Cascade		
BL	Boil		
RP	Rapid Associated with broken standing waves		
GL	Glide Associated with smooth flows		
RU	Run Associated with rippled flows		
RI	Riffle Associated with unbroken standing waves		
PO	Pool		
PR	Ponded reach		
SW	Disconnected standing water [1]		
DE	Connected standing water (Deadwater) [1]		

[1] See Survey Code Sheet [1] for illustration of lotic habitat features

[2] any large wood pieces: >1m x >10cm dia, accumulation or fallen tree

SPECIAL FEATURES

Record if P = Present or E = Extensive

Description	**A**	**P** (even if <1%)	**E**	Photo Ref (optional)
Leafy debris				
Braided / side channels				
Fen (low wet land, grassy				
Marsh / Bog				
Carr (wetland, woody veg)				
Water meadow				
Floating mat				
Floating reed bed				
Waterfall >5m				
None				

Tree features	**A**	**P**	**E**
Channel shading			
Overhanging boughs			
Exposed bankside roots			
Underwater roots			
Fallen trees			
Coarse woody debris			

Tree distribution	**Left bank**	**Right bank**
None		
Isolated/scattered		
Regularly spaced individuals		
Occasional clumps		
Semi-continuous		
Continuous		

ECOLOGICAL CHARACTERISTICS

Circle if present, add others if observed

Invertebrates (Aquatic)	Dragonfly - Damselfly - Banded Demoiselle - Midge - other (specify)
Invertebrates (Terrestrial)	Stag beetle - Bombus humilis - Beetles - other (specify)
Mammals	Water vole - Bats esp. Daubentons (state spp if known) - Hedgehog - other (specify)
Amphibians / Reptiles	Grt.crested newt - Common frog - Toad - Grass snake - Adder - Slow worm - other (specify)
Birds	Black redstart - Grey Heron - Grey Wagtail - House martin - House sparrow - Kingfisher - Robin - Sand Martin - Swift - other (specify)
Fish	Bullhead - Minnow - other (specify)
Trees	Mistletoe - Black poplar - Crack Willow - Alder (healthy or diseased?) - other (specify)
Plants	Water Crowfoots (Ranunculus sp.) - Water Cress - Purple Loosestrife - Common Reed - other (specify)
Additional observations	

URS_Beta Test_v2.1 (2010) SURVEY CODES & SPOT CHECK KEY [1]

Sheet 1 SURVEY REACH CHARACTERISTICS

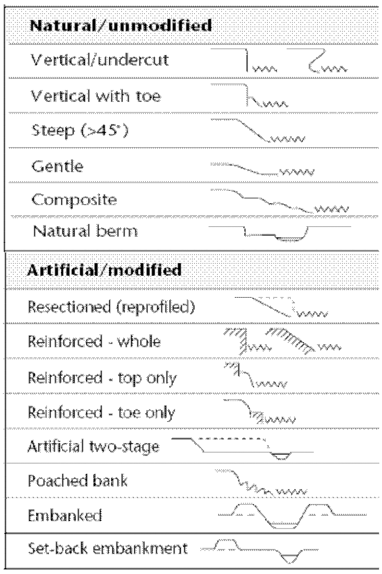
Planform code	Description	Definition
SN	Semi-natural	River follows its natural course (pre-urban), may be naturally meandering or naturally straight: natural planform
ST	Engineered	River has been moved from its natural course and a new channel made: artificially meandering
ME	Engineered: sinuous/ meandering	River has been artificially straightened so that it possesses a low sinuosity or completely straight planform
RE	Recovering	River is either (i) attempting to regain original course by actively modifying its banks through significant erosion / deposition, or (ii)

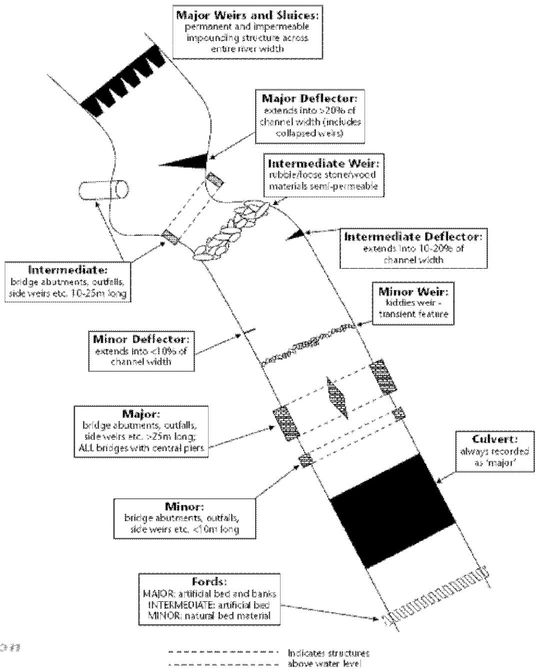
Cross profile code	Description	Definition
SN	Semi-natural	Cross section of the river has not been altered in any way (N.B. Only possible with a natural planform)
RE	Restored/ Recovering	Cross section restored to its original form through a restoration scheme or by active erosion / deposition by the river
CL	Cleaned (vegetation/ structures removed)	General cross section virtually untouched but has a neat clean (low roughness) appearance, especially at the bank toe
EN	Enlarged	Over widened / over deepened channels - especially obvious where concrete channels have been created. Typically in over widened
TS	Two-stage	Characteristic step appearance to the bank - narrower bottom section contains average to low river flows, and widened upper section
RS	Resectioned	Characteristic trapezoidal shape to the river channel. Also often over widened as a result of engineering

Sheet 2 SPOT-CHECK MEASUREMENTS - see reverse of sheet

Sheet 3 CUMULATIVE MEASUREMENTS - ARTIFICIAL FEATURES

Bank profiles:

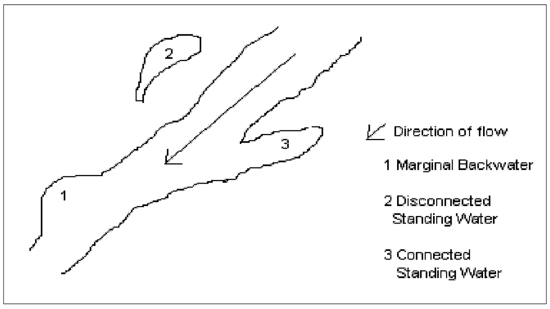




Source: *River Habitat Survey Manual: 2003 version*

Sheet 4 CUMULATIVE MEASUREMENTS - HABITAT FEATURES

Lotic habitat features:



URS_Beta Test_v2.1 (2010) SURVEY CODES & SPOT CHECK KEY [2]

Sheet 2 SPOT-CHECK MEASUREMENTS

WITHIN 1m TRANSECT

Bank Material Code	Description
AR	Artificial
BE	Bedrock
BO	Boulder
CO	Cobble
GS	Gravel/ Sand
CE	Crumbly earth
EA	Earth
CL	Clay
NV	Not visible

Bank Protection Code	Description
CC	Concrete
CB	Concrete and brick
BR	Brick / laid stone
BW	Builder's waste
SP	Sheet piling
WP	Wood piling
RR	Rip rap
GA	Gabions
RE	Reeds (planted)
WS	Willow spiling
WO	Washed out
NO	None

Marginal & Bank Feature Code	Description
NV	Not Visible
NO	None
EC	Eroding Cliff
SC	Stable Cliff
PB	Unvegetated Point Bar
VP	Vegetated Point Bar
SB	Unvegetated Side Bar
VS	Vegetated Side Bar
NB	Natural Berm

Flow Type Code	Description
BW	Broken standing wave
UW	Unbroken standing wave
CH	Chute
FF	Free Fall
CF	Chaotic Flow
UP	Upwelling
RP	Rippled
SM	Smooth
NP	No perceptable flow
DR	Dry

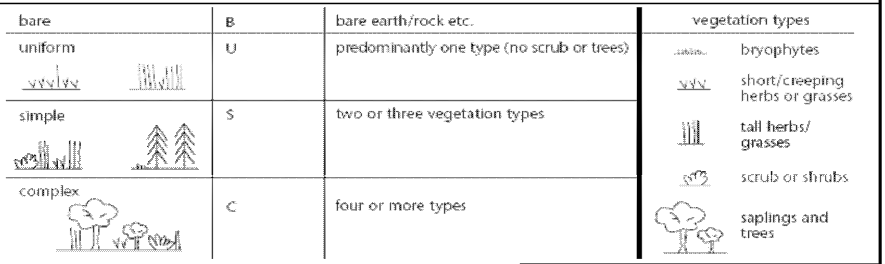
Channel Substrate Code	Description
AR	Artificial (concrete)
BE	Bedrock
BO	Boulder
CO	Cobble
GP	Gravel-Pebble (circle dominant type)
PE	Peat
SA	Sand
SI	Silt
NV	Not visible

Channel Feature Code	Description
NV	Not Visible
NO	None
EB	Exposed Bedrock
RO	Exposed Boulders
VR	Vegetated Rock
MB	Unvegetated Mid-channel Bar
VB	Vegetated Mid-channel Bar
MI	Mature Island
TR	Trash

WITHIN 10m TRANSECT

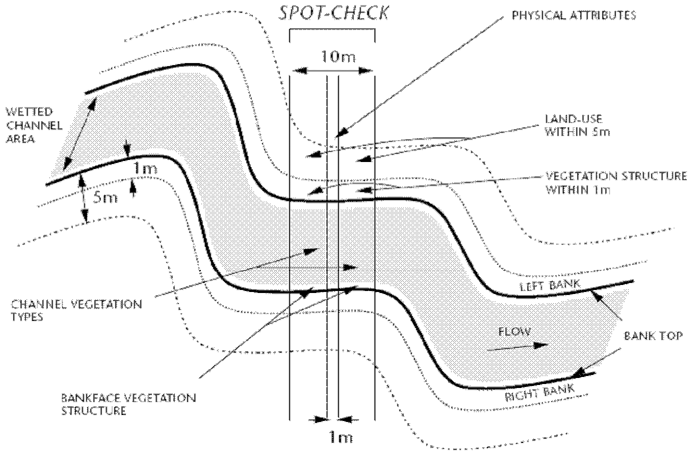
BANK STRUCTURE CODES:

(NB Bank top structure assessed within 1m)



bare	B	bare earth/rock etc.
uniform	U	predominantly one type (no scrub or trees)
simple	S	two or three vegetation types
complex	C	four or more types

Figure 1 Diagram showing dimensions for spot-checks



Source: *River Habitat Survey Manual: 2003 version*

Land use code	Description *(NB within 5m of bank top)*
Re	Residential
Cm	Commercial
In	Industrial
Ic	Industrial/Commercial
Tr	Transport infrastructure (roads, railways)
Sw	Sewage Treatment Works
Ld	Landfill/Refuse Deposits
Dr	Derelict Land
Cr	Cropland
Pa	Pasture
Fe	Closed Feeding (Intensive stock production)
Or	Orchard
Co	Coniferous
Dd	Deciduous
Ow	Open Woodland
He	Heathland
Sc	Scrub
Op	Open Parkland (Community Grass etc.)
Rc	Recreational Land (Playing Fields)
Ce	Cemeteries/Crematoria
La	Lake / pond
Rv	Reservoir
Ca	Canal
Qu	Quarry
Tb	Tributary

Appendix B: Feedback from URS Workshop, June 2011

Urban River Survey Workshop Evaluation Form plus responses from 16 participants (a-p)
24th June 2011

Please take a moment to answer the following questions. Your comments are a very important contribution as we develop the URS training to meet practitioners' needs.

(n/c) = no comment

1) **How do you anticipate the URS will be relevant and/or useful in your current role?**
   a) Potentially very relevant, borough officers will be able to survey waterways in the borough, RHS being too time consuming
   b) Assessing the state of the river and where/how we might improve it. Assessing restoration projects.
   c) As a pre/post project monitoring tool
   d) Have learned the methodology without previous. I have found useful to validate my understanding of it, allowing me to correct some of my surveys
   e) It would be useful to identify restoration and evaluate schemes before & after
   f) To help pinpoint stretches which would benefit from restoration, better use of limited resources
   g) Would hope to use it in ecological surveys
   h) Very useful in the urban catchments of the Cray and Shuttle, as RHS is not in that much detail
   i) It will be useful as a general tool for me to assess requirements and plan teams work
   j) In planning projects on stretches of river in urban areas
   k) Allow me to conduct my fieldwork for my dissertation
   l) Good to improve strategic management & prioritising project ideas for different rivers
   m) To monitor / evaluate the urban river sections within the Royal Parks (Bushey / Richmond Parks)
   n) Training for future use.
   o) We will use the URS on all subsequent river surveys along the River Quaggy so that others may access the database for future reference
   p) understanding how URS can be used to analyse and improve the Wandle in future, including URS in combination with other data on eg fish populations to maximise beneficial habitats and mitigate problems; also informing my own perceptions when I'm looking at other urban rivers

2) What are the most valuable things you learned during today's sessions that will help you to use the URS in your work?

a) Interpretation of the definitions in the field

b) How to do it, interpretation of different classifications

c) How it differs from RHS / chance to ask(?) specific examples about characteristics

d) Different view of recording features coming to a common similar(?) answers (or indices)

e) The website is a very useful tool to express this information to a large audience

f) Write down what you see! Don’t overanalyse

g) That it exists! & general methodology

h) Actually going out and trying to conduct a survey was very useful

i) All, no part more valuable than another

j) In general, use of the forms and an understanding of the codes

k) How to conduct the survey precisely

l) (n/c)

m) Field interpretation of definitions, Better understanding of how the survey is conducted

n) The idea that it is just about the surface values & engineering of the river opposed to the RHS

o) How engineered rivers may be classified

p) the morning workshop focused my attention on the many variables in past river modifications – will also help me to identify partial / bedded-in river restoration work!

3) Was there anything you did not understand during today's sessions? Please provide specific examples.

a) some terminology, but these were explained during the workshop

b) no

c) no

d) the measurements can be confusing (specifically bank)

e) (n/c)

f) (n/c)

g) Some confusion over terminology of a ‘bank’ vs a ‘channel’ and where the vegetation survey should stop, Fig 1(Dimensions for spot checks) doesn’t tally with text on the spot check sheet

h) No – very well explained

i) No

j) (n/c)

k) (n/c)

l) (n/c)

m) I need to understand more about time costs of survey & possible outcomes (cost/benefit). I'm keen and willing to gather data but wonder how <u>useful</u> the resulting data will be to my organisation.

n) (n/c)

o) No, all was clear

p) no, all very well explained by Lucy and Angela (even to the layman like myself!)

4) How can we improve the URS training workshop programme?

a) Workshops to be split into smaller groups with a facilitator on each group. Group size 3-4 max

b) It was great

c) Some more details as to how the analysis is conducted i.e. groupings of features / indices etc

d) (n/c)

e) Perhaps enough a bit more questions /discussion in the morning

f) Perhaps give out the manual before hand, so more time is spent out in the field

g) More time – e.g. first day similar to today, second day doing a full survey in small groups / pairs and double checking with Lucy & Angela

h) Maybe a smaller group size. Potentially enter the river with waders on to survey, but only in group sizes small enough not to impact on the river.

i) Get into watercourse explore more on the practical.

j) Have more than one cafetierre of coffee? Smaller group

k) (n/c)

l) Have longer in the field splitting into small numbers to practice doing sections of the form then coming together again to discuss results

m) I think it will become better when the methodology is finalised & the terms/measured used are finalised, then training can be in the <u>definitive</u> method, this session was a bit experimental (fair enough) so hard to have full confidence in it.

n) Maybe more practical application – look at whether people are all classifying things in the right way

o) Probably with a more rigorous assessment of practical applications for URS

p) excellent workshop – I'd say difficult to improve except with updates on methodologies etc as they develop

5) **What other specific comments do you have?**

a) workshop to go through a worked example first, each group to carry out with each facilitator

b) none yet

c) I still need to discuss the analysis and results for the survey to discuss if it would be effective in the way I would like to use it. Web site and future plans sound really exciting

d) (n/c)

e) It would be useful to stay in touch to see how the project goes

f) For pollution indicators I would add ‘sewage fungus’

g) Great work – keep going!

h) I think that this will be a useful tool, and although today people mentioned an number of additional types of descriptions they wanted added the most important thing to highlight that we are modelling real life and not everything can be accounted for.

i) None

j) Additions to form – spell check for wier(s)

k) (n/c)

l) Looking forward to seeing the development of the website!

m) I’m very grateful for the time & effort that went into the session. I learned a lot and I had no previous experience of URS / RHS.

n) (n/c)

o) I think the URS will complement the RHS specifically with regards to urban rivers

p) very well done – look forward to seeing these methodologies being more widely adopted!

Please include your contact details if you would like a response to any points!

Thank you!

Appendix C: Interview Guide questions

Please note: This list of questions was developed as a guide and prompt for the researcher and not presented directly interviewees.

A. Interviewee profile

1. About you *[i.e. Name / Job description / Background?]*
2. About your organisation - What is the core focus of your organisation? *[Environmental / Social / both?]*
3. Briefly, what were your role and responsibilities in this river project?

B. Questions re: partnership in planning / delivery of river restoration at *[name of restoration project]*

1. Why did (*your organisation*) get involved in this project?
2. What were the main **aims** and objectives for (*your organisation*)?
3. What **role** was (*your organisation*) able to play in the (i) **planning** and (ii) **delivery** of the project?
4. What were the main **contributions** that (*your organisation*) was able to make to the planning / delivery stages of the project?
   [e.g. resources / expertise / etc?]
5. Were there any **conditions** attached to these contributions?
6. Were any of the other members of the **partnership** more important to (*your organisation*)'s role in the planning and delivery of this project? …………..e.g. sub-groups / explaining process / technical details / etc?
7. What were the main **challenges** that came up via the planning / delivery stages in this project?
   a. Were there any **conflicts** between (*your organisation*)'s objectives and those of other partners?
   b. Were there any **constraints** on achieving (*your organisation*)'s objectives due to planning / delivery processes?
8. What **solutions** were found to meet these challenges?

C. Facilitation and tools

1. What kind of Environmental / Social / combined information was available to (*your organisation*) and other partners to support the planning / delivery of this project?
2. Which information did you find most useful?
   [i.e. Environmental / Social / combined?]

3. Were there any major knowledge gaps for (*your organisation*)?
   [e.g. missing or inaccessible?]

D. River Survey / Ecosystem services information

1. Are you familiar with the URS (RHS) outputs? Or Ecosystem Services Assessment (ESA)?
2. Based on your understanding and experience of the URS and ESA, do these assessment methods provide useful information for planning / delivery and decision making?
   a. URS
   b. ESA
3. What are the most useful types of output for (*your organisation*)?
   [e.g. .for raising support / funding / other?]

E. Finally….

1. What was your overall experience of
   a. the integration of environmental and social targets through this project?
   b. working in an interdisciplinary partnership?

Appendix D: Ecosystem Services Assessment outputs for Mayesbrook Park Restoration Project: Adapting to Climate Change

(Source: Everard, Shuker and Gurnell, 2011)

Annex 1: Detailed results of ecosystem services assessment of the Mayes Brook restoration at Mayesbrook Park

Tables A1.1 to A1.4 below document the ecosystem services assessments of the benefits arising from the Mayes Brook restoration respectively for provisioning, regulatory, cultural and supporting services, using methods explained in the body of this document.

Table A1.1: Assessment of provisioning services from the Mayes Brook restoration

Provisioning services and the methods and assumptions used for their evaluation	
Fresh water	There is no abstraction from the Mayes Brook catchment today, and the brook also discharges into the saline Barking Creek with is not abstracted for public supply. Therefore any contribution to water quality and resource availability is not used for abstraction. **Annual value = £0**
Food (e.g. crops, fruit, fish, etc.)	There is no food production on the site, nor any river-dependent farming downstream in this urban area. There is believed to be informal abstraction by bucket for private gardens, but the small scale of this is likely to make the benefit negligible. There are fish in the Mayes Brook but none that are suitable for food. **Annual value = £0**
Fibre and fuel (e.g. timber, wool, etc.)	There is a potential for hay harvesting on the new one-hectare floodplain habitat. A reduced bi-annual mowing regime could conceivably yield benefits in relation to the use of the hay cuttings for either mulch or compost within the park site. Prunings of other vegetation, including the extensive tree planting, could also constitute a resource (wood chip biofuel, etc.) rather than a net disposal cost. These resources may be most valuable if they can be processed (chipped / shredded) and used on site as compost or mulching materials thus reducing additional transportation costs. The installation of a biofuel facility would require considerable initial capital and maintenance investment which would need to be offset against the longer term gains. These are merely highlighted as potential development options and are not part of current plans, so are assessed as zero value for the current assessment. **Total monetary value = £0**
Genetic resources (used for crop/stock breeding and biotechnology)	Restoration of more natural river and floodplain habitat can be assumed to protect or restore biodiversity with its associated genetic resources. This is likely to improve resilience of biodiversity, creating an ‘island’ within this heavily impacted urban environment. However, there appear to be no markets of informal uses of this genetic resource which is therefore ascribed a zero value.

	Annual value = £0
Biochemicals, natural medicines, pharmaceuticals	This mirrors the observations for genetic resources above, for which a zero value is ascribed despite the likely overall contribution to ecosystem diversity and resilience (which are accounted for as cultural and supporting services). Maintaining viable populations of native flora and fauna in an impoverished urban setting is a valuable insurance for a future when the biochemical value of these resources may be recognised and required. **Annual value = £0**
Ornamental resources (e.g. shells, flowers, etc.)	We can expect local people to enjoy flowers on the restored and accessible floodplain, but this will be included as a cultural value as it has no substantial provisioning benefits. **Annual value = £0**
Gross annual provisioning service benefits	**Unlike related rural ecosystem services case studies (Everard, 2009a, 2010 and submitted; Everard *et al.* 2009; Everard and Jevons, 2010), the provisioning service outcomes of this urban river ecosystem restoration are assessed as zero (£0) though some development options are highlighted for 'fibre and fuel'.**

Table A1.2: Assessment of regulatory services from the Mayes Brook restoration

Regulatory services and the methods and assumptions used for their evaluation	
Air quality regulation	Increase of vegetation diversity, including tall herbs and grasses in the floodplain and less intensively mown areas as well as tree plantings, can be anticipated to make a substantial difference to air quality. This happens through the three mechanisms of: • particulate fallout (especially PM10s) • metabolism of SOx, NOx, ozone, etc. • adsorption of metals Given the very high urban population densities surrounding the park, there are many potential beneficiaries, and the scheme could be considered and optimised as a 'green lung' for the city. The Defra (2007b) *Air Quality Strategy for England, Scotland, Wales and Northern Ireland* July 2007 estimates that the costs of the health impact of man-made particulate air pollution experienced in the UK in 2005 was between £8.5 billion and £20.2 billion a year, which the UK Government's Environmental Audit Committee report on air quality (House of Commons, 2010) considers to be an underestimate. Pollution is most intense in urban areas, largely related to traffic which is the biggest source in the UK. It is therefore a conservative estimate that 8,000 people (approximately .00013 of the UK population) of people living within 0.5 km of the Park boundary suffer £1.105 million of health impact from fine airborne particulates (based on the low Defra estimate and also from summary statistics for adjacent wards from the UK Census 2001, http://neighbourhood.statistics.gov.uk/dissemination/). Quantification of air clean-up and its knock-on implications for urban health are both highly uncertain, so if we take a conservative estimate that the air cleansing properties of regenerated vegetation in the park can have a 0.1% impact on air-related health issues for just these neighbouring people, the theoretical benefit would be £1,105. It is accepted that this is highly uncertain, but scientific methods do not support a more robust estimate.

	Annual value = £1,105
Climate regulation (local temperature/precipitation, greenhouse gas sequestration, etc.)	We can expect a marginal difference in carbon sequestration as a result of tree growth, less intensive mowing, and potential organic matter accumulation in floodplains. Quantification of these components: • Sequestration in trees. SWIMMER (2007) reviews scientific literature on soil organic content and standing crop, noting that riparian rewetting can increase soil carbon from 20,324 C t ha^{-1} (g m^{-2}), recorded for floodplain permanent grassland, towards soil carbon of 26,064 C t ha^{-1} for floodplain woodland. The incremental difference of 5,740 C t ha^{-1} resulting from tree planting and growth for 3 additional hectares of trees, which, yields a total additional soil carbon sequestration of 172 t C ha^{-1} a^{-1} over 100 years. To this is added the standing crop of trees (SWIMMER, 2007 calculated that alder forest has a 100-year annualised average carbon storage of 65 t C ha^{-1} a^{-1}) which accounts for additional sequestration of 195 t C ha^{-1} a^{-1}. Multiplying the sum of annualised woodland soil and above-soil sequestration by the current marginal cost of carbon @ £27 per tonne yields a forestry-related carbon sequestration benefit value of £9,909 per annum. • Sequestration in reedbeds and wetland habitat is uncertain, since natural and constructed freshwater wetlands can be both sources and sinks of carbon, depending upon factors such as their environmental setting and age (Kayranli *et al.* 2010). Therefore, we attribute zero to their valuation in this assessment • Sequestration in floodplain soils. Zehetner *et al.* (2009) found rapid carbon accumulation during the initial 100 years of floodplain soil formation, with rates exceeding 100 g m^{-2} a^{-1} (= 1 t C ha^{-1} a^{-1}). Applying this value to the 1 ha of created floodplain yields a total carbon sequestration rate of 1 t C a^{-1} equating to an annual value (@ £27 per tonne) of £27. • Mowing regime. It is uncertain how quickly or permanently a change in mowing regime will affect soil carbon, so this potential benefit is not quantified in this study. • Net carbon sequestration value. The sum of the above three annual benefits is £9,936. The contribution of urban 'green spaces' to microclimate can be significant. 8,000 people live within a half-a kilometre of the park's boundaries (UK Census 2001 summary statistics for wards adjacent to Mayesbrook Park: http://neighbourhood.statistics.gov.uk/dissemination/). More than 2,000 excess deaths were reported in England and Wales during the major heat wave that affected most of western Europe in 2003, of which London accounted for a disproportionately high quantity compared to other English regions (Haines *et al.* 2006). The elderly and deprived are known to be the most susceptible groups to heat stress (Kovats, 2008). The World Health Organisation (2004) identified heat stress in cities as an important issue. Optimal planning of the floodplain and associated tree planting can moderate ambient temperatures for park users and make a substantial contribution to providing cool refugia for aquatic species by buffering diurnal stream temperatures (Rutherford *et al.* 2004; Broadmeadow *et al.* 2010). This will enhance the local climate but also have a moderating impact on the riparian corridor downstream of the park. However, evidence linking these various strands of data together are elusive, necessitating yet more assumptions. For the current purpose, and for want of further supporting evidence, we will use a benefit value for the combined microclimate effects of restored habitat at 50% of the 'air quality' value = £553. The gross value for climate/microclimate benefits is equal to the sum of carbon

	sequestration (£9,936) and health improvement (£553) = £10,489. **Combined annual value = £10,489**
Water regulation (timing and scale of run-off, flooding, etc.)	Mayesbrook Park lies within ‘Zone 3b Functional Floodplain’ of the *London Borough of Barking & Dagenham: Strategic Flood Risk Assessment (SFRA) Level 1* (Jacobs, 2008). Dagenham and Barking has a dense population (4,680 /km^2 according to Wikipedia, accessed 20th May 2010) A runoff curve method used by the United States Department of Agriculture (Marek, 2009) allows comparison of percentage runoff from different land uses and soil types. Assuming that the soil supports a moderate infiltration rate and is currently under poor condition trampled mown grass, runoff is estimated at 79%: • 1 ha will be converted to floodplain which is equivalent to the USDA ‘meadow’ cover (58% runoff due to better infiltration, saving 21%); • 3 ha will be converted to additional woodland across the whole park (eventually 60% runoff for intermediate condition woodland, which is the likely condition given the likely heavy use, saving 19% of runoff); • mowing regime can be expected to change runoff characteristics, possibly to intermediate between ‘poor’ and ‘good condition grassland (60% saving 19% runoff) over a conservative area of 20ha; and • a mean annual precipitation of 583.6 millimetres (http://www.bbc.co.uk/weather/world/city_guides/results.shtml) …this yields a conservative saving of 26,729 m^3 of rapid runoff averted per annum which, although some infiltrating water may enter the Mayes Brook as baseflow, will suppress flood peaks. This may be particularly significant under climate change scenarios under which it is anticipated that more intense rainfall events and wetter winters will affect the London area. Residential and industrial areas adjacent to the Mayes Brook downstream of the Park are potential beneficiaries of this restoration, as are those adjacent to the Barking Brook although this is indirect and not assessed. Assuming that risks to 500 properties at damage estimates of £20,000 per property are reduced by 0.1% (one year in a thousand risk reduction on an annual basis), this yields an annual damage estimate of £10,000. There are further opportunities for the Mayesbrook Park restoration including taking a wider ecosystem-based approach to park hydrology using such innovations as green roofs, porous paving, SuDS schemes and detention basins in park infrastructure and landscaping. These potential hydrological benefits are not quantified or values in this study as they do not (yet) feature in scheme design. **Total monetary value = £10,000**
Natural hazard regulation (i.e. storm protection)	This will mirror observations for microclimate resulting from roughness created by trees, floodplain and reduced mowing regime, all of which will absorb storm energy which is likely to increase under climate change scenarios. The authors could not find any studies helpful in quantifying this effect, so it is therefore not assessed in this study. **Annual value = £0**
Pest regulation	Restoration of habitat can restore stocks of natural crop pest predators in lowlands. However, there are few crops to suffer damage in this vicinity beyond those in gardens. Uncertainties about this service, and how to value it, mean that a neutral value is assigned. **Annual value = £0**
Disease	Disease regulation is contentious. On the one hand, improved river and riparian

regulation	habitat is effective in eliminating waterborne pathogenic microbes (Nuttall *et al.* 1997). However, there is a perception of risk of malaria spreading under climate change forecasts, emphasising the value of the microclimate benefits (which will not be valued here in order to avoid double counting). Given the uncertainties, this service is not valued. **Annual value = £0**
Erosion regulation	The current (reinforced pre-restoration) condition of the Mayes Brook means that erosion is not a significant issue on the riparian zone. However, there is deposition of fine silt and organic particulates on the stream bed which requires periodic dredging largely as part of emergent vegetation removal. Following restoration, the floodplain can be expected to settle silt. Dredging/trimming costs (fines and vegetation management of overhanging branches and emergent plants in the channel) are estimated at £1,000 per 100 metres per annum. For the restored Reaches 3 and 4, with a combined length of 1 km, this yields a total of £10,000. Assuming that this management will, conservatively decline by 50%, the saving will be £5,000 per annum. Depending upon the details of stream design, if there is sufficient energy in the brook channel post-restoration then this may move fine particulates out of the channel and also result in erosion of coarse sediment from banks which is dumped into channel to build habitat. All river energy absorbed in the park may contribute to averting erosion downstream. **Annual value = £5,000**
Water purification and waste treatment	The additional habitat provided by improved river and floodplain habitat, in addition to pollutants detained or transformed by attenuated runoff and the ‘reedbed treatment system’ effect that may occur if the abandoned brook course (flood relief channel) is allowed to vegetate up and if reedbed systems are installed at lake inlets, will undoubtedly contribute to the physico-chemical purification of water and associated waste substances. This does not affect abstracted water as none is removed from the brook downstream. However, it is possible to conceptualise the restored brook habitat through Mayesbrook Park as green infrastructure that serves to clean up the environment including the catchment. If this opportunity is seized and optimised in brook corridor/backwater design, benefits will accrue to ‘habitat for wildlife’. Since there are risks of double-counting with ‘fresh water’ and also ‘nutrient cycling’ and ‘habitat for wildlife’ (for the last two see under supporting services below) services, this service is not assigned a value here. **Annual value = £0**
Pollination	Restoration of habitat, particularly restored floodplain, can restore stocks of natural pollinators which may be beneficial for the high local population who may be getting more interested in cultivation. Currently, there is no clear market for this service, and uncertainties about future markets mean that this service is not yet valued. **Annual value = £0**
Gross annual regulatory service benefits	**The substantial £26,504 regulatory service benefits stemming from habitat enhancement in this urban park relate almost entirely to public health and risk management, demonstrating the significant role of Mayesbrook Park in enhancing the wellbeing of the neighbourhood**

Table A1.3: Assessment of cultural services from the Mayes Brook restoration

Cultural services and the methods and assumptions used for their evaluation	
Cultural heritage	There is little historic significance on site, the whole unit only being established in the 1930s. However the unfinished Italianate gardens represent the historic significance of changing priorities that were associated with the onset of war in 1939. The lakes are also relics of this era, dug for sand and gravel extraction for the sprawl of urban development. **Annual value = £0**
Recreation and tourism	There are many potential visitors to the park, mainly by local people rather than people from further afield. Currently, lack of amenity and fear of crime means that park usage is low, beyond the football, basketball and cricket fields and the kayaking. Lake restoration will also boost frequency and safety of kayaking which is currently inhibited by blue-green algal blooms as well as resumption of angling. Outdoor gyms and linkage of the park to cycle-ways will enhance use, as will construction of the visitor centre/café and particularly employment of a warden (a bid is currently in to the ‘Access to Nature’ scheme). This is anticipated to increase local use significantly. A park user survey carried out over 28 days between January – June 2009 revealed an average of 262 visitors per day, ranging from 59 to 1103 visitors on a Saturday in May 2009. These data indicate that the majority of park users are families or groups (27%) followed by dog walkers (16%) and walkers (12%). Just under 8% of all park users were recorded as unaccompanied children. This is likely to be associated with the close proximity of the secondary school to the park and sports facilities (Shears, 2009). The increase in usage observed on the Ladywell Fields park was over 250% in the year following the restoration of the parkland and the River Ravensbourne that traversed it (RRC, 2008). When applied to the Mayesbrook Park this would result in a post-project daily average visitor number of 656 persons. O’Gorman *et al.* (2009) record a value loss of £16.90 per person-day where closure of a waterway deters visitors. The product of these values is £11,086, providing an estimate of the overall value of increase post-restoration use of Mayesbrook Park. The creation of employment through the cafe and visitor centre, in terms of catering and cleaning services, also represents a key benefit to potentially local employees both financially and in terms of quality of life and health gains. If the equivalent of one full time post is created, a value might be ascribed in terms of the resulting non-payment of Job Seekers Allowance (currently £65.45 / week for a single person aged over 25 years www.direct.gov.uk/). An annual cost saving could be estimated as £65.45 x 52 = £3,403.40 If the value of Housing Benefit is included at the Local Housing Allowance rate for Barking and Dagenham of £71 per week for a 1 bed shared rental (https://lha-direct.voa.gov.uk/) this would represent an additional annual cost saving of £3,692. The average annual Council Tax per household in LBBD is £999 (www.upmystreet.com/local/council-tax-in-barking.html) based on a household of two adults, giving a per capita value of £499.50 The combined saving in benefits gives an annual total figure for each full time job created of £7,595 The creation of 1.5 x Conservation Warden posts (valued at 1.5x £25,000, including National Insurance contributions, giving a total benefit of £37,500) is not included here as a benefit as it is accounted for as part of the overall costs of the restoration scheme representing an investment in intended benefits.

	Annual benefit = £18,681
Aesthetic value	Increasing this value is a key target of the Mayes Brook restoration, including the increase in facilities, habitat, etc. These aspects have been highlighted through the results of the 2009 public consultation which reflected the desires of the community for aesthetic improvements. However, these benefits have been picked up in other services and are not double-counted here. **Annual value = £0**
Spiritual and religious value	These values are not known, but are not considered to be significant. **Annual value = £0**
Inspiration of art, folklore, architecture, etc.	Schools use the park for artistic projects (funded by Natural England) at present, and it is anticipated that this will increase in future as the aesthetics and biodiversity of the park increases. Monetising this is not straightforward so no value is assigned at this stage. **Annual value = £0**
Social relations (e.g. fishing, grazing or cropping communities)	This is believed to be substantial as the park is under used today but use will be increased as a result of improvements made under the restoration plan. The restored brook, wetland, lakes and naturalised park areas will be a focus for clubs (fishing, boating, bird-watching, etc.) and for informal use by children and parents, dog-walkers, etc. Several areas specifically designed for Natural Play are included within the Mayesbrook Landscape Masterplan (LBBD, 2009). These will be enhanced by passive supervision of young park visitors. Woodland and wetland trails as well as fitness stations located around the park will also encourage park visitors to interact with the landscape and each other whilst building common interest relationships with each other within the natural environment. Furthermore, the restoration provides opportunities for the creation of local interest and ‘Friends of’ groups which have been shown to increase social cohesion in other examples of river restoration, such as the River Brent at Tockyngton Park (Mbeke, 2008). The value of volunteer work within the park also offers a per capita evaluation potential in terms of the value of maintenance or services to the landscape / community. Studies on other restoration schemes (such as Everard, 2010, on the River Glaven and also project work on London’s River Wandle www.wandletrust.org) use estimates of the value of volunteer days contributing to this social capital. The increased involvement of local young people in the park and environmental activities (angling, kayaking, etc.) would lead to a greater sense of ownership of the space leading to a reduction in crime and vandalism. It is considered that the likely impact on adjacent property prices will capture, or at least act as a market surrogate, for these diverse values. CABE (2009) note uplift in adjacent property values as a significant effect of proximity to urban parks, and Petts *et al.* (2002) provide case studies highlighting the impact of proximity to good quality or restored urban rivers upon property prices. CABE (2005) demonstrate a 5% to 34% (average 7%) uplift in property value resulting from park renovation, though figures vary widely in response to a range of factors. The area to the south of Mayesbrook Park is assumed not to be affected as it is separate by a railway line. However, average house prices were explored in residential areas to the west (^{c}£240,000) and east (^{c}£135,000) of the park, noting that these were probably also affected by proximity to the primary and secondary schools, transport connections and other factors. Based on the average 7% increase cited by CABE (2005), the average uplift for properties would be £16,800 to the west and £9,450 to the east (mean value = £13,125).

	Taking a conservative assessment that this will affect properties within 0.25 km of the Mayesbrook Park boundary (approximately two streets), accounting for 596 houses, this produces a gross uplift of £7,822,500. Spread over the 25-year payback period of the scheme, this amounts to an annual value of £312,900. **Annual value = £312,900**
ADDENDUM: Education resources	The habitats, sporting and amenity opportunities in the restored park will provide a diversity of educational benefit ('mini-beast', wetland and woodland trails, environmental chemistry, climate change studies, etc. and other subjects on the Natural Curriculum). There is both a large secondary and a primary school immediately adjacent to the park adjacent. Evidence from the Trout in the Town project organised by the Wild Trout Trust (www.wildtrout.org) on the River Wandle has shown that approximately 9,000 children have had involvement in the rearing and release of trout fry in that catchment (Wandle Trust, 2010). While the Mayes Brook may not yet represent a suitable location for this type of project, it indicates the far-reaching benefits of locally accessible high quality natural environments for ecological education. In the absence of resources for detailed social surveys, an averted cost method is used. Access to these facilities at the Park will avert travel costs for access to alternative facilities, which may also act as a surrogate for the value of missed opportunities where schools elect not to transport students to other sites. We assume that the averted cost will total ten coaches per year @ (conservatively) £500 each, yielding a value of £5,000. In considering this benefit, we believe that further investment in, or modification of plan designs for, facilities such as an outdoor classroom (as put in place in the restoration of the River Quaggy in Sutcliffe Park) could further increase this value. Training provided to volunteers involved in tree planting also confers a hidden value to the community in terms of enhancing skills and employability for participants. The value of training varies according to the nature of work performed and is therefore identified as an area for further research but this service is not yet valued within this report. **Annual value = £5,000**
Gross annual cultural service benefits	**Contribution of the park restoration to cultural services is significant given its urban location and dense adjacent population, providing substantial benefits in terms of recreation, social relations and educational opportunities estimated at some £336,581**

Table A1.4: Assessment of supporting services from the Mayes Brook intervention

Supporting services and the methods and assumptions used for their evaluation Note: The Millennium Ecosystem Assessment classifies this category of ecosystem services as those entailed in the internal functioning and resilience of the ecosystems. As such, they are disastrous if lost yet often hard to quantify in operation. Many of our cultural practices have in fact depended on 'consumption' of these services, for example the way that industrial-scale farming 'mines' soil structure and fertility.	
Soil formation	Soil accretion will be enhanced by improved and diversified habitat. However, to avoid any potential double-counting with both carbon sequestration (climate regulation) and erosion regulation, this service is not quantified here. **Annual value = £0**
Primary production	Primary production will be enhanced by improved and diversified habitat. However, to avoid any potential double-counting with services such as

	provisioning uses of hay and tree trimmings (fibre and fuel), this service is not quantified here. **Annual value = £0**
Nutrient cycling	Enhanced habitat will make a significant contribution to nutrient spiralling and transformation (for example through vegetative uptake, nitrification, denitrification and related ecosystem processes) based on 24 ha (20 hectares of the park scheduled for relaxed mowing regime, 3 ha of new woodland and 1 ha of created floodplain) and: • using pessimistic data drawn from a literature review (McInnes *et al.* 2008) that total N removed by storage and export is 170 kg N ha^{-1} a^{-1} (on flat land) and total P removed by storage and export is 25 kg P ha^{-1} a^{-1}; also • applying market values of £8.32 kg^{-1} ha^{-1} a^{-1} for N removal costs and £12.00 kg^{-1} ha^{-1} a^{-1} for P removal (also McInnes *et al.* 2008); and • assuming that degraded grassland (short mown and disconnected from watercourses) may have operated at 50% nutrient cycling efficiency …this yields a total annual economic value for nutrient cycling (based on nutrient removal costs averted) in restored habitat of £20,573. A cautionary note here is that there is no clear market for this theoretical economic benefit, though averted costs of eutrophication of downstream reaches of the Mayes Brook and Barking Creek and impacts on those using these watercourses could be considered amongst actual benefits. **Annual value = £20,573**
Water recycling	Habitat restoration/creation can be expected to enhance water recycling through processes such as floodplain storage, groundwater exchange and recycling of evaporation in more complex vegetation structure including trees. However, to avert double-counting with benefits valued under the ‘water regulation’ and also ‘climate regulation’ (microclimate) services, these are not quantified or monetised here. **Annual value = £0**
Photosynthesis (production of atmospheric oxygen)	Photosynthetic oxygen generation will be enhanced by improved and diversified habitat. However, to avoid any potential double-counting with services such as provisioning uses of hay and tree trimmings (fibre and fuel), this service is not quantified here. **Annual value = £0**
Provision of habitat	One of the major purposes of urban park restoration of this urban watercourse and park is the improvement of habitat for wildlife. Whilst values such as the contribution of habitat and species to aesthetics, education and wider appreciation of nature and landscape are already captured as cultural services, and therefore not double-counted here, there are dimensions of habitat enhancement that have on-overlapping value. Restoration of habitat and biodiversity in Mayesbrook Park will also serve as: • an inoculum of biodiversity for the river system (including fish, macrophyte and invertebrate species revealed in an Environment Agency (2008, unpublished) survey) and wider terrestrial habitats as and when they are regenerated; • an island or ‘stepping stone’ for biodiversity to migrate across the otherwise inhospitable urban landscape; • a site into which wildlife may migrate and colonise, including for example the water vole populations remaining in the Mayesbrook downstream of the culvert to the south of the park); and

	- suitable habitat for the seed bank to recolonise, noting that seed banks have been found to remain intact in urban river corridors and to germinate and spread under restoration conditions (Gurnell *et al.* 2006). A further benefit is that, if the restoration is designed such that the brook channel remains dynamic, this will suppress dominance by weedy vegetation species. Valuation of this benefit is necessarily complex, but can be approached by assessing averted costs for bespoke nature conservation goals which, conservatively, may be estimated at £1,000 per 100 metres of river length. The restored 1 km of combined Reaches 3 and 4 of the Mayes Brook yields a value of £10,000. **Annual value = £10,000**
Gross annual supporting service benefits	**The supporting services enhanced by restoration of this currently environmentally-impoverished parkland are of significance in enabling other more readily-valued services to be performed, but also in terms of nutrient recycling and provision of habitat with a cumulate evaluated benefit of £30,573**

End of Annex 1