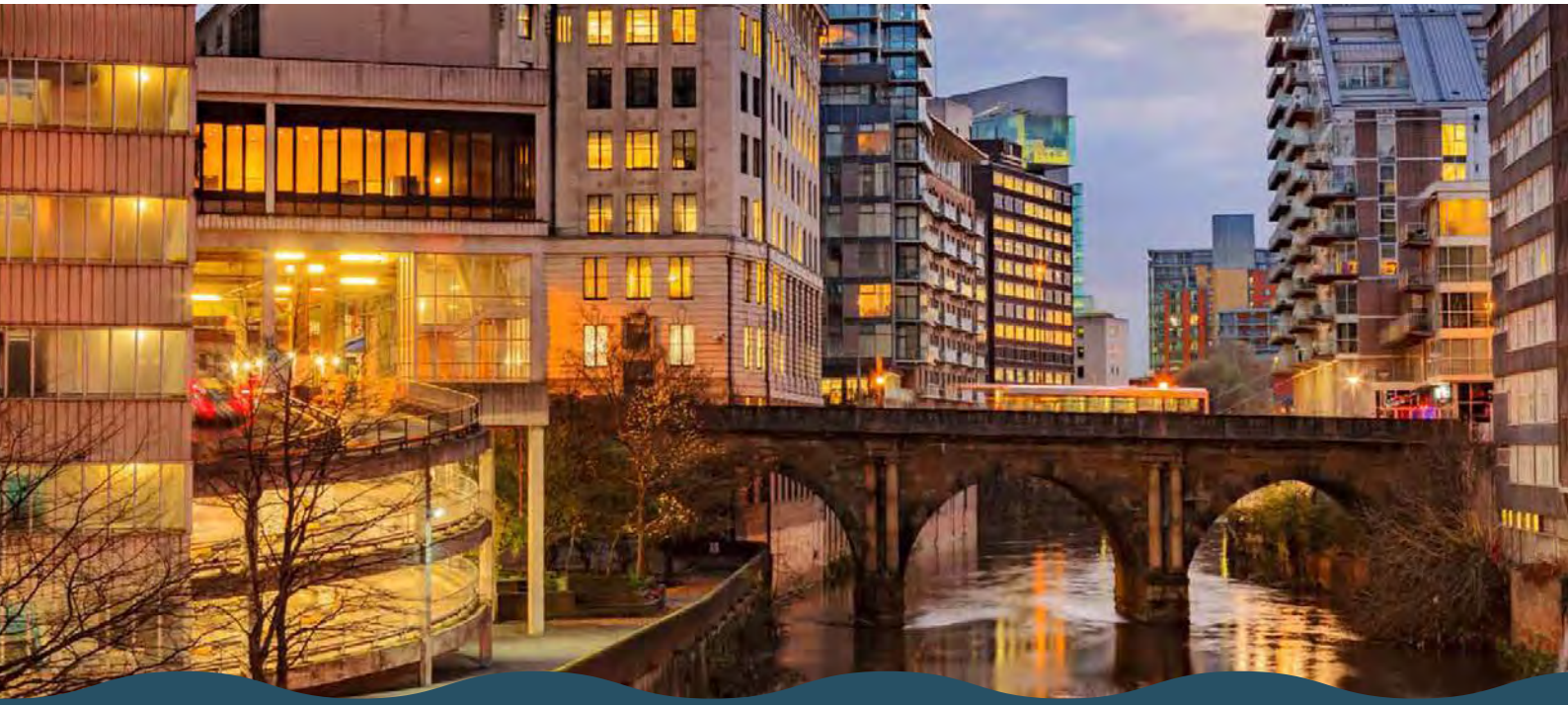
NATURAL COURSE

OUR WATER. OUR FUTURE

Irwell Management Catchment

Natural Capital Account & Ecosystem Services Opportunity Mapping



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About Natural Course

78% of water bodies in North West England are failing to meet a good ecological status* and solutions are often found to be too expensive to implement.

Natural Course is a collaboration of organisations in North West England from public, private and third sector who, together, will seek cost-effective solutions to improving water quality across urban and rural landscapes, sharing best practice across the UK and Europe.

*Environment Agency, North West River Basin District 2015

Natural Course will:

- Test and inform best practice in achieving UK and EU legislation in water quality
- Use the North West River Basin District as a flagship project and share best practice with the UK and Europe
- Make better use of resources, share ownership of complex issues and maximise outcomes through a collaborative approach of organisations from public, private and third sector.

Join the conversation #NaturalCourse

IRWELL MANAGEMENT CATCHMENT

NATURAL CAPITAL ACCOUNT AND ECOSYSTEM SERVICES OPPORTUNITIES MAPPING

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1.0 Overview

This report identifies the significant natural capital value of the Irwell Management Catchment's (IMC) waterbodies. The report shows how the waterbodies, even in their current heavily modified condition, deliver a range of ecosystem services (ESS) which underpin the economy and society of the IMC. This is a highly urbanised area, including several towns and cities in Greater Manchester and east Lancashire, all of which are expected to experience population growth which, if not planned sensitively, will place pressure on the natural environment.

The report demonstrates how the natural capital of the IMC's waterbodies can be maintained and enhanced through investment in ESS. For each ESS, the report identifies the primary opportunities for investment in projects which will address historic and ongoing environmental and public health problems, and will help sustain future economic and population growth..

1.1 The report provides compelling evidence that the natural environment of the IMC provides significant and sustained value to society. Given the continuing need to reverse historic environmental decline, create a more inclusive society and prepare for new development and climate change, this report shows where investment will enhance the ESS provided by the IMC's waterbody corridors; and thus increase the IMC's natural capital.

1.2 This report was prepared by TEP and Vivid Economics between September 2017 and March 2018, working to the Natural Course Project Steering Group[1], with stakeholder input provided through two workshops[2]. Natural Course is an EU LIFE Integrated Project (LIFE IP Ref: LIFE17IPE/UK/027) aimed at integrated water management through accelerating the objectives of the Water Framework Directive (WFD) and improved flood risk management.

Key IMC Stats:

- The IMC incorporates the Rivers Irwell, Croal, Roch, Medlock and Irk and their tributaries.
- These rivers drain the western Pennines and flow through the Pennine Fringe and Greater Manchester before joining the Manchester Ship Canal at Salford Quays (see Figure 1).
- The IMC includes the local authorities of Manchester City, Salford City, Trafford, Tameside, Oldham, Bolton, Bury, Rochdale, Blackburn with Darwen and Rossendale.
- The local authorities Bury and Rochdale are wholly within the IMC.
- The IMC contains 28 waterbodies which are the focus of this report.

[1] Greater Manchester Combined Authority, Environment Agency, United Utilities, Natural England, the Rivers Trust and others

[2] Refer to Appendix B for dates, scope, attendance and topics covered

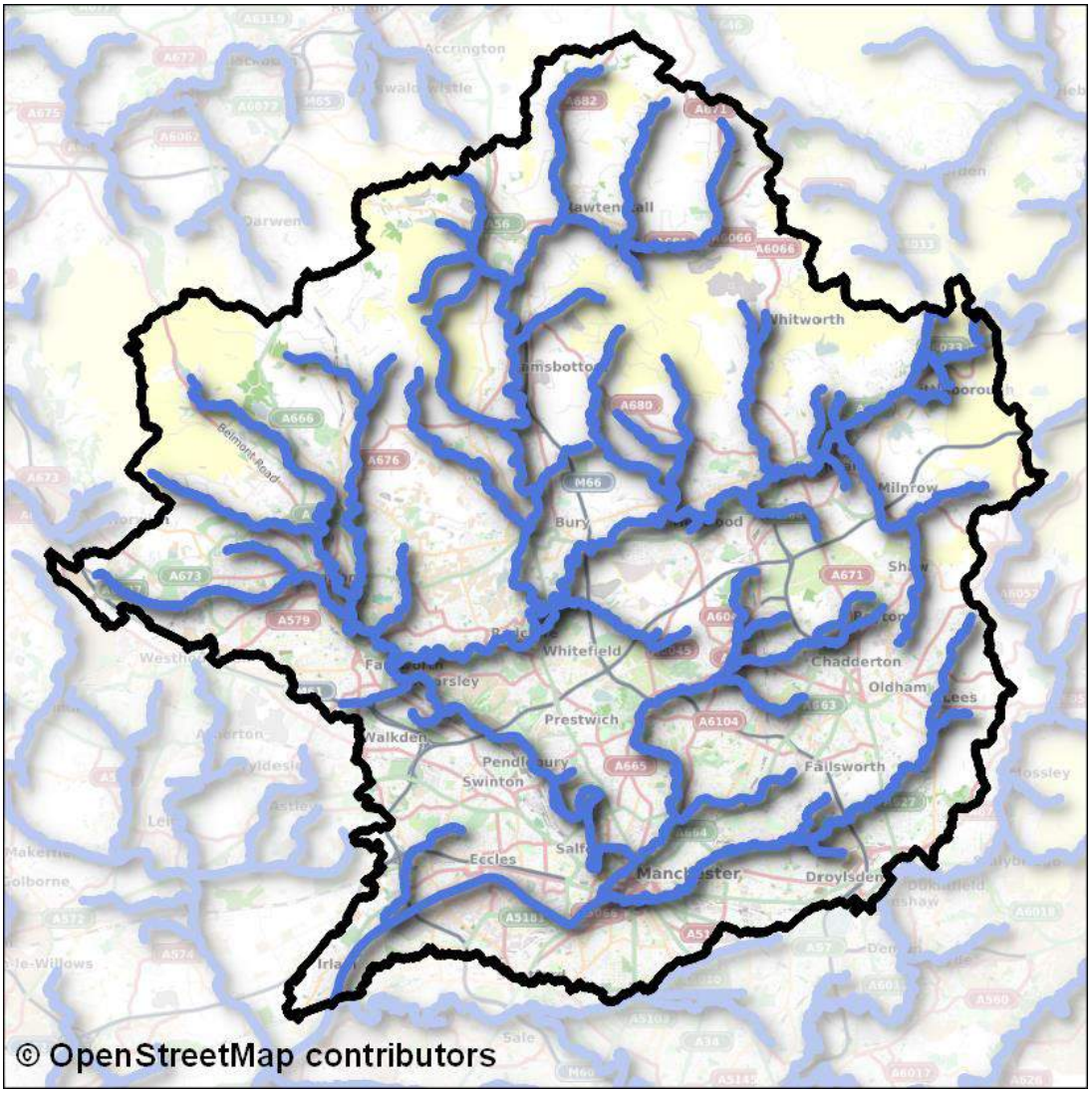


Figure 1: IMC Boundary, Showing the Waterbodies Studied

Natural Capital Account

1.3 This report shows that the natural environment alongside the IMC's waterbodies[3] has an existing natural capital value of £418 million per year. The study area makes up 12% of the IMC and therefore the value of the natural environment throughout the whole IMC will be higher.

1.4 The natural capital value arises from ESS which flow to society. Values of £105 per annum/per head arise from the combined physical and mental health benefits associated with use and enjoyment of waterbodies and associated greenspaces.

1.5 The study area also provides ESS with significant values in water quality, water resources, amenity, flood risk mitigation and carbon sequestration. There are tangible natural capital values associated with agriculture (food production) and timber production in the study area, however these will be much higher across the IMC as a whole.

[3] Based on a corridor encompassing the river, the floodplain, a 100m corridor beyond floodplain and the neighbourhoods within or directly adjoining the corridor

1.6 Biodiversity and ecological networks, air quality mitigation, noise reduction and temperature regulation are ESS which cannot currently be monetised for the IMC[4], but are nonetheless highly valued by local residents and in policy and legislative terms. Biodiversity although not monetised does form a key component of each valuation.

1.7 The IMC's natural capital benefits:

- **Communities neighbouring the waterbodies**:
  Benefit from improved health, increased property values and general amenity arising from views, recreational opportunity, reductions in adverse effects from urban noise, air quality and peak summer temperatures.
- **Greater Manchester and Lancashire's local authorities:**
  Benefit from avoided costs principally in terms of healthcare and flood response.
- **Water companies, infrastructure providers, canal operators and renewable energy generators:**
  Benefit from water supply, reduced water treatment and pollution control costs.
- **The city and global economy:**
  Benefits from carbon sequestration, flood resilience, improved commercial opportunities on the waterfront and improved mental and physical health in society.

Continuing Need for Environmental Improvement

1.8 Water has been at the heart of the economy for hundreds of years and the IMC and Upper Mersey Management Catchment waterbodies enabled Manchester and neighbouring cities and towns to rise to the world stage during the Industrial Revolution. However, the adverse consequences of uncontrolled urbanisation led to significant declines in the aquatic environment.

1.9 In the past 30 years, sustained campaigning, regulation and environmental action have enabled many of the IMC's waterbodies to begin their recovery. As the aquatic environment has improved, new economic and social opportunities have opened up, including angling, waterfront commerce, leisure and recreation and consequential benefits to public health. The watercourses, floodplains and associated open land are critical green infrastructure (GI) underpinning economic growth, community cohesion and environmental sustainability.

1.10 There is still much to achieve, however, and the WFD is a key driver for change.

1.11 The WFD's goal for the IMC is for Heavily Modified Water bodies (HMWB) to reach good ecological potential and good chemical status by 2027[5].

1.12 26 of the 28 waterbodies within the IMC are "heavily modified"; in other words they are still suffering from pollution, reduced water quality, obstructions to fish passage and artificial bank and channel modifications.

Local, National and Global Ambitions

1.13 The IMC in its current condition is not fully contributing to Greater Manchester's vision to be a world city known for the quality of its environment.

[4] For reasons associated with methodological uncertainties still being resolved through UK and international dialogue; or due to lack of granular data at the scale of the IMC river corridors.
[5] Defra and Welsh Government (2014) Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment

1.14 Greater Manchester Combined Authority (GMCA) is made up of 10 Councils who work together to tackle issues which affect the entire city region. GMCA, along with the Mayor Andy Burnham, has a vision as a Green City Region to "invest in the natural environment to respond to climate change and improve quality of life for all"[6] .

> *"Greater Manchester is one of the country's most successful city regions. Home to more than 2.7 million people and with an economy bigger than that of Wales or Northern Ireland, our vision is to make it one of the best places in the world. We're getting there through a combination of economic growth, and the reform of public services".*
>
> - Greater Manchester Combined Authority (GMCA)

1.15 The UK Government's 25 Year Environment Plan seeks a step-change in water quality and seeks to embed a natural capital approach in decision-making. The plan sets out ambitious plans to protect and grow natural capital, identifying the social and economic benefits the environment provides. The Plan builds on the advice of the Natural Capital Committee and states *"Making the vision of a healthier environment a reality requires solid foundations: comprehensive, reliable data; strong governance and accountability; a robust delivery framework, and everyone to play a role*".

1.16 Importantly, the 25 Year Environment Plan aspires to expanding the net gain approaches used for biodiversity to include wider natural capital benefits. This will enable local planning authorities to target environmental enhancements that are needed most in their areas and give flexibility to developers in providing them.

1.17 The United Nation's Sustainable Development Goal 6 states "*Everyone on earth should have access to safe and affordable drinking water. That's the goal for 2030 ….. protecting wetlands and rivers, sharing water-treatment technologies … leads to accomplishing this goal*".

Greener Urban Development

1.18 Greater Manchester and Lancashire will experience significant development over the next 25 years. This provides an opportunity to ensure new development:

- Leads to greater protection and management of the IMC's waterbodies ecosystems; and
- Benefits from the proximity of the natural environment.

1.19 The ten local planning authorities in Greater Manchester (Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford and Wigan) are preparing the Greater Manchester Spatial Framework (GMSF) which will set out the approach to housing and employment land across Greater Manchester for the next 20 years. A draft of the GMSF was published for consultation in October 2016 and a second draft is currently in preparation.

[6] https://www.greatermanchester-ca.gov.uk/info/20005/green_city_region

1.20 The draft GMSF published in October 2016 describes the economic growth planned for Greater Manchester as being high level and well above baseline forecasts. The GMSF states that there is a very strong emphasis on directing new development in locations that minimise environmental impacts and reduce the need to travel. The GMSF describes the pressures on natural capital as already high and how this will intensify in the next 25 years with the projected population growth. The draft GMSF provides a vision for GI and natural capital in Greater Manchester.

> *An integrated network of high quality green infrastructure will extend throughout Greater Manchester, providing a broad range of environmental services as well as contributing to the character and attractiveness of places, supporting good health, and boosting competitiveness. Key components of this network will include the river valleys, canals, trees, woodlands and parks that extend throughout Greater Manchester, as well as the major character areas of the uplands in the east and north and the lowland wetlands in the south-west where extensive areas of habitat will be restored.*
>
> - Greater Manchester Combined Authority (GMCA)

The Natural Course Project

1.21 Natural Course is an EU LIFE Integrated Project aimed at integrated water management through accelerating the objectives of the WFD, improved flood risk management and enhanced biodiversity. The project spans the North West England River Basin District with an early focus on the IMC.

1.22 Due to the scale, complexity and sometimes high costs of WFD delivery, Natural Course focuses on integration; both between project partners and more widely among organisations and sectors that can contribute to integrated water management. Natural Course works through the established network of Catchment Partnerships and employs a natural capital approach to tackling the challenges presented by the WFD and increased flood risk management where possible.

1.23 A specific action of Natural Course is to:

- Identify reaches of heavily modified channel in the IMC;
- Carry out interventions to help re-naturalise the channel and improve the ESS they provide; and

- Mobilise funds from new sources illustrating the benefits that a more naturalised channel can bring from a natural capital perspective.

Why a Natural Capital Approach?

1.24 A natural capital approach is taken in this study to robustly identify how habitats in the study area contribute to the economy in the IMC.

1.25 Natural capital refers to the physical stock of natural assets, such as water and woodland, in a given area. These natural assets consequently provide a flow of services that underpin many aspects of the economy, referred to as ESS.

1.26 The Government's 25 Year Environment Plan acknowledges that when the natural capital approach is used, better and more effective decisions can be made that support environmental enhancement and help deliver benefits multiple benefits.

1.27 The Plan places the effective management of the UK's natural capital at the centre of its objectives. This means that the environment's contribution to the economy is made visible, which places greater emphasis on making management decisions that preserve and improve the condition of natural assets in order to enhance the value of services they provide to people.

1.28 The natural capital approach also offers an effective means of illustrating the level of services provided by natural assets across different groups of people or places. Equity in the availability and provision of ESS is frequently cited as a key objective for stakeholders who manage these assets, owing to the important role natural capital has a range of economic and social indicators, such as health.

1.29 Measurement of ESS can provide information about beneficiaries. This can be used to provide evidence about best locations to invest in maintaining and enhancing natural capital to deliver greatest public benefit.

1.30 A natural capital approach can build partnerships between organisations working in the same territory who rely on the ESS flowing from waterbodies; for example partnerships between developers who benefit from the land value uplift arising from greenspace adjacent to waterbodies, landowners who rely on such greenspace to provide flood resilience, local authorities and health providers whose societal costs are reduced as people take outdoor exercise in such spaces, and utility/infrastructure companies who can take advantage of the waterbodies for abstraction, energy generation and drainage management. Such partnerships have a mutual interest in investing in projects which maintain and enhance the flow of ESS.

ESS Opportunities

1.31 The cost of re-naturalising HMWB is high, as can be improvements to the water quality and natural resources adjacent to HMWB, and therefore this project provides a basis for determining the natural capital benefits that such interventions could bring.

1.32 This study identifies, for each land parcel in the waterbodies corridors, the opportunities that changes in land use or management could bring in terms of improved ESS. ESS Opportunity maps are included for:

- Water quality;
- Flood risk mitigation;
- Leisure and recreation;
- Amenity;
- Biodiversity and ecological networks;
- Carbon sequestration; and
- Air quality.

1.33 The interactive maps, hosted on MappingGM[7], enable an overview of where interventions would be most likely to enhance ESS and in turn, increase the natural capital of the IMC.

1.34 In an age of ongoing pressures on public services, it is important to explore nature-based approaches to waterbody restoration, especially where these cost less to implement and manage than engineering solutions. For example, planting reed beds and aquatic vegetation, removing litter, eradicating non-native invasive plant species, changing the way land is managed adjacent to waterbodies, changing the landscape adjacent to waterbodies by planting trees and sowing wet meadow grass seed; are all measures which can absorb or avoid pollutants and sediment reaching watercourses, whilst simultaneously enhancing biodiversity and ecological networks, amenity and public health.

Innovation and Areas for Continued Development

1.35 This study has developed some natural capital valuation and ESS Opportunity Assessment techniques appropriate to an urban catchment:

- Use of exclusively open data to compile the habitat maps and subsequent ESS opportunity maps means that the methods can be replicated and adapted by other urban catchment partnerships.
- Creation of a land surface model from high-resolution LIDAR has identified flowpaths and pooling areas for surface water; these assist ESS opportunity

[7] https://mappinggm.org.uk/gmodin/?lyrs=tep_ecosystem_services#os_maps_night/10/53.5069/-2.3201

mapping for water quality, carbon sequestration and biodiversity and ecological networks.

1.36 Future iterations could include:

- Updates to the Natural Capital Account once national standards are agreed for valuation of biodiversity and ecological networks and noise reduction;
- Use of detailed soils mapping to highlight greenspaces and agricultural land where water quality and carbon sequestration ESS could most feasibly be improved through good soil husbandry;
- Use of contaminated land registers to inform opportunity mapping for water quality;
- Detailed urban tree canopy information available consistently across the entire IMC;
- Inclusion of local intelligence about which greenspaces could host footpath/cycleways that effectively shift pedestrians and cyclists away from busy main roads i.e. mitigating adverse effects of air quality;
- Flood modelling to assess the effectiveness of natural flood management interventions in mitigating downstream risks; and
- Application of the natural capital valuation and ESS opportunity map across the whole of Greater Manchester and/or the IMC.

2.0 Purpose of this Report

> The focus of the first phase of Natural Course is the development of an integrated water management framework for the IMC through a series of 'Preparatory Actions'. This report sits alongside these studies as a Preparatory Action by identifying reaches of the IMC that are HMWB and considering possible interventions that help to re-naturalise the channel and/or improve the ESS they provide.

2.1 To date the following studies have been published or are in hand:

- River Irwell Management Catchment – Evidence & Measures, Final Report February 2017;
- Natural Flood Risk Management Modelling in the River Irwell Catchment (Rivers Trust and JBA Consulting, 2017);
- Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments (City of Trees, 2017); and
- The Irwell Catchment Ecology Project (GMEU, ongoing).

2.2 This report contains a Natural Capital Account and an ESS Opportunity Assessment and links to maps hosted on MappingGM.

2.3 The Natural Capital Account highlights the existing value arising from flows of ecosystems services. It will help the IMC Partnership and other key stakeholders promote the value of the IMC to a wide range of stakeholders.

2.4 The ESS Opportunity Assessment and Maps will help the IMC Partnership and other key stakeholders develop a portfolio of projects which understand and address water quality, water quantity and biodiversity and ecological networks and deliver parallel enhancements to improve public health and carbon sequestration.

3.0 Approach

> This Chapter summarises the methods used for the study. It describes which ESS are scoped into the valuation and opportunity assessment processes, and how the valuation and opportunity assessment has been carried out.

3.1 Full details of the methods and relevant sources of information are found in:

- Appendix A: Master Datasets;
- Appendix B: Summary of Stakeholder Workshops;
- Appendix C: Habitat Types Definitions and Mapping Protocols;
- Appendix D: Ecosystem Services Valuations and Natural Capital Methodology;
- Appendix E: Opportunity Assessment - Methods and Mapping Protocols;
- Appendix F: Mapping Tool User Guide;
- Appendix G: Natural Capital Accounts by Waterbody and District;
- Appendix H: Ecosystem Opportunities Assessment by Waterbody; and
- Appendix I: District Valuations and Opportunity Mapping.

3.2 This study provides detailed evidence to support stages 1 to 5 of the development of the Natural Capital Account (Stage 4) and ESS opportunity mapping (Stage 5) (see Figure 2).

3.3 The study also provides commentary on Stages 6, 7 and 8 to enable the IMC Partnership and other key stakeholders including funders and investors to prepare a portfolio of projects for investment (Stage 9).

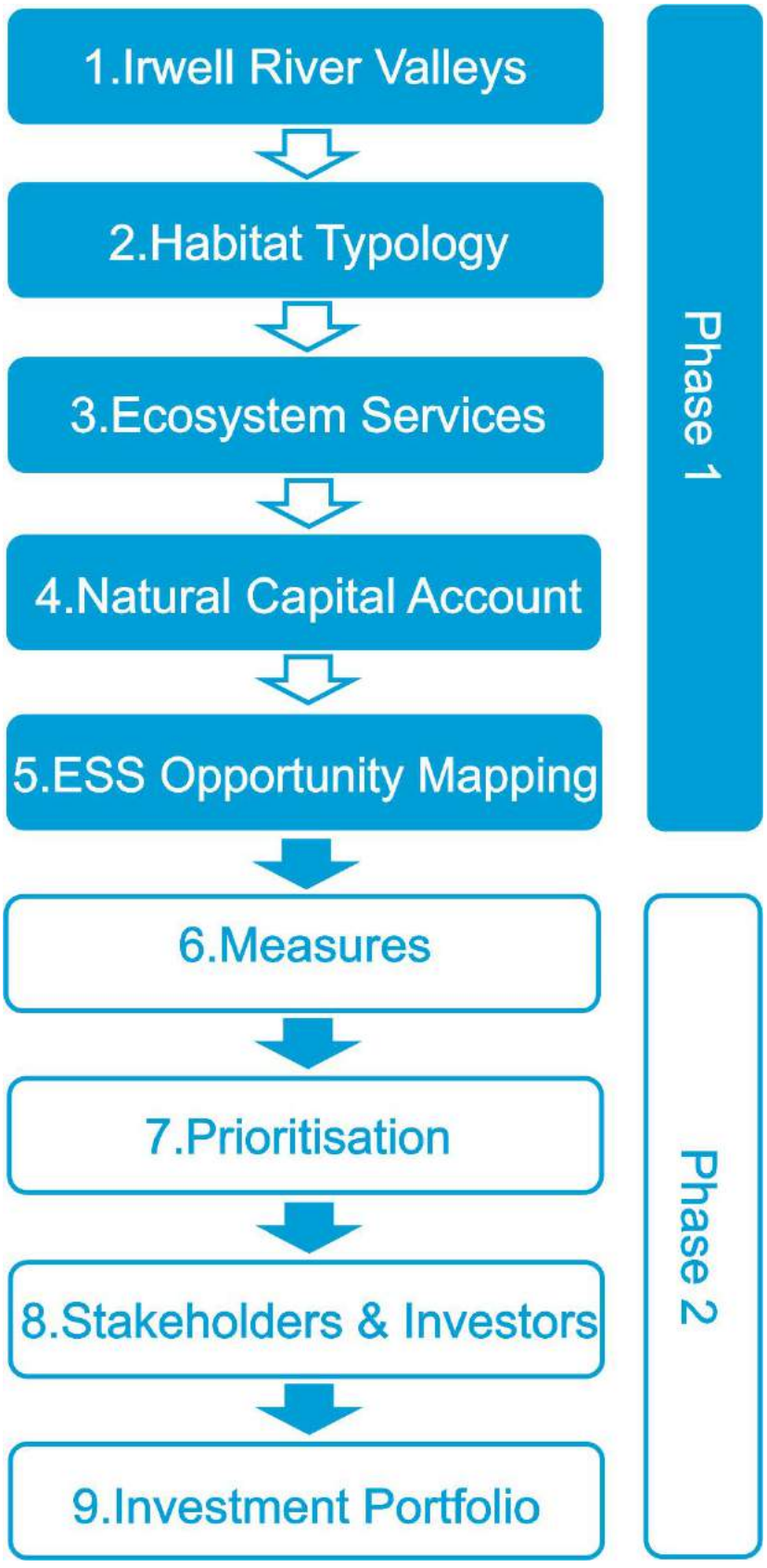


Figure 2: Methodology

Stage 1: Defining the Geographical Scope of the Study

3.4 The WFD Surface Water Operational Catchment Cycle 2[8] was used as the overall project boundary for the IMC. Appendix A lists all the datasets accessed for the study.

3.5 In agreement with the Natural Course Project Steering Group a 100 metre buffer was applied to the 1 in 100 year flood zone alongside each waterbody. This formed the study area for the Natural Capital Account and the ESS Opportunity Assessment (Figure 3).

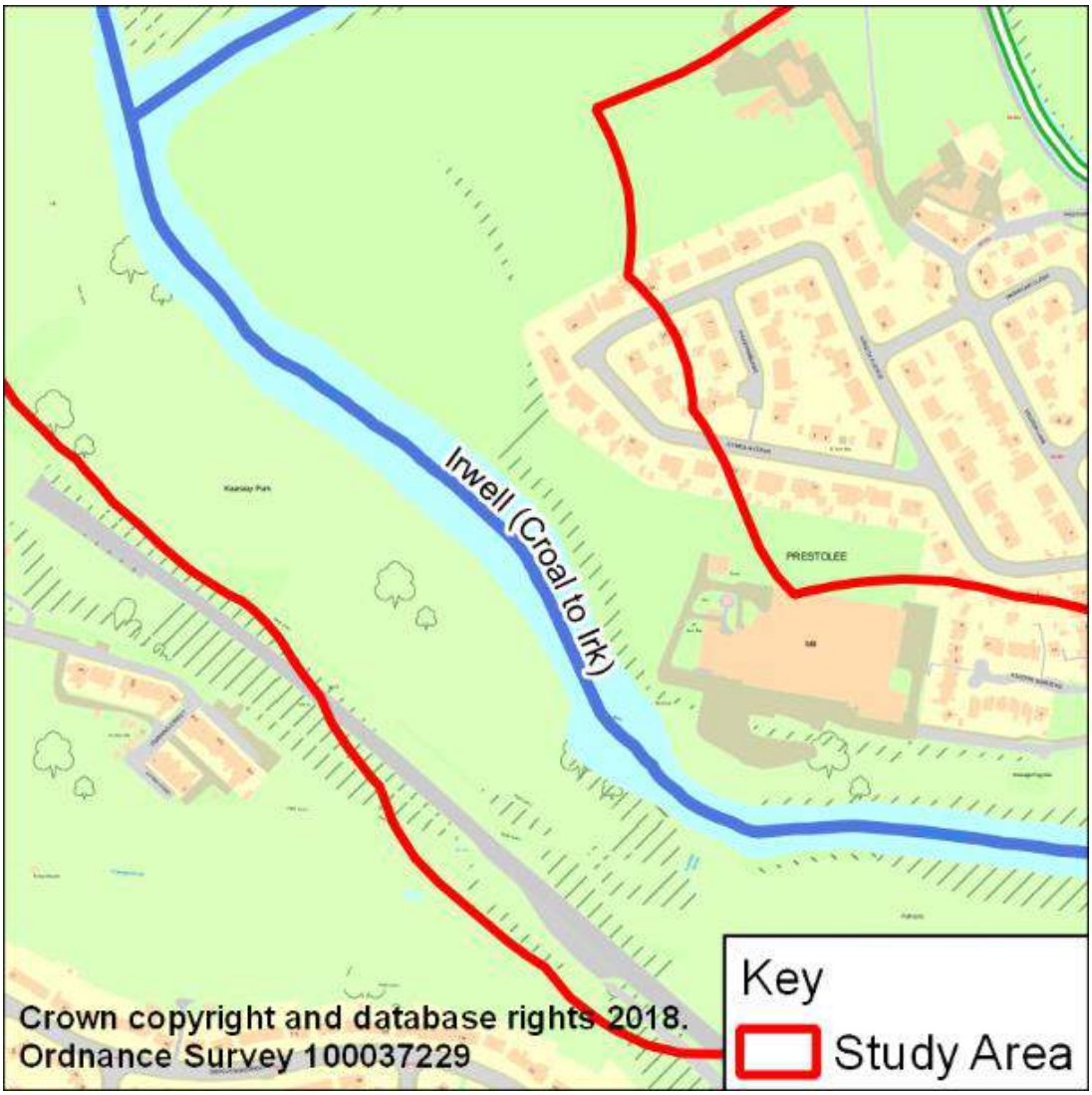


Figure 3: Study Area, including River, Flood Zone and 100m Buffer

3.6 This 100m buffer allows the study to focus on the waterbodies of the IMC; ensuring the ESS most closely linked to the waterbodies are assessed.

3.7 Nevertheless, the Natural Capital Account does include neighbourhoods and communities within and beyond the study area. For example, census boundaries that overlap with each study area are assessed in full, even if only part of the boundary lies within the study area. Middle Super Output Areas (MSOAs) were used to assess the socioeconomic characteristics, such as population and house prices.

[8] Environment Agency 2016

3.8 ESS Opportunity Assessment maps also consider influences beyond the 100m buffer, particularly in relation to land that is hydrologically connected to the waterbodies.

Stage 2: Mapping Habitat Types

3.9 Mapping broad habitat types and sub-types enables the identification of natural capital assets. Each habitat type or sub-type can deliver or support one or more ESS.

3.10 A breakdown of the habitats present in the study area is provided in Chapter 4 (Study Area Overview). Appendix C describes the process of habitat mapping, data sources and limitations.

3.11 A sample section of the broad habitat mapping is shown in Figure 4. The habitat mapping, including sub-types, is contained within the opportunity mapping data layer provided on MappingGM.

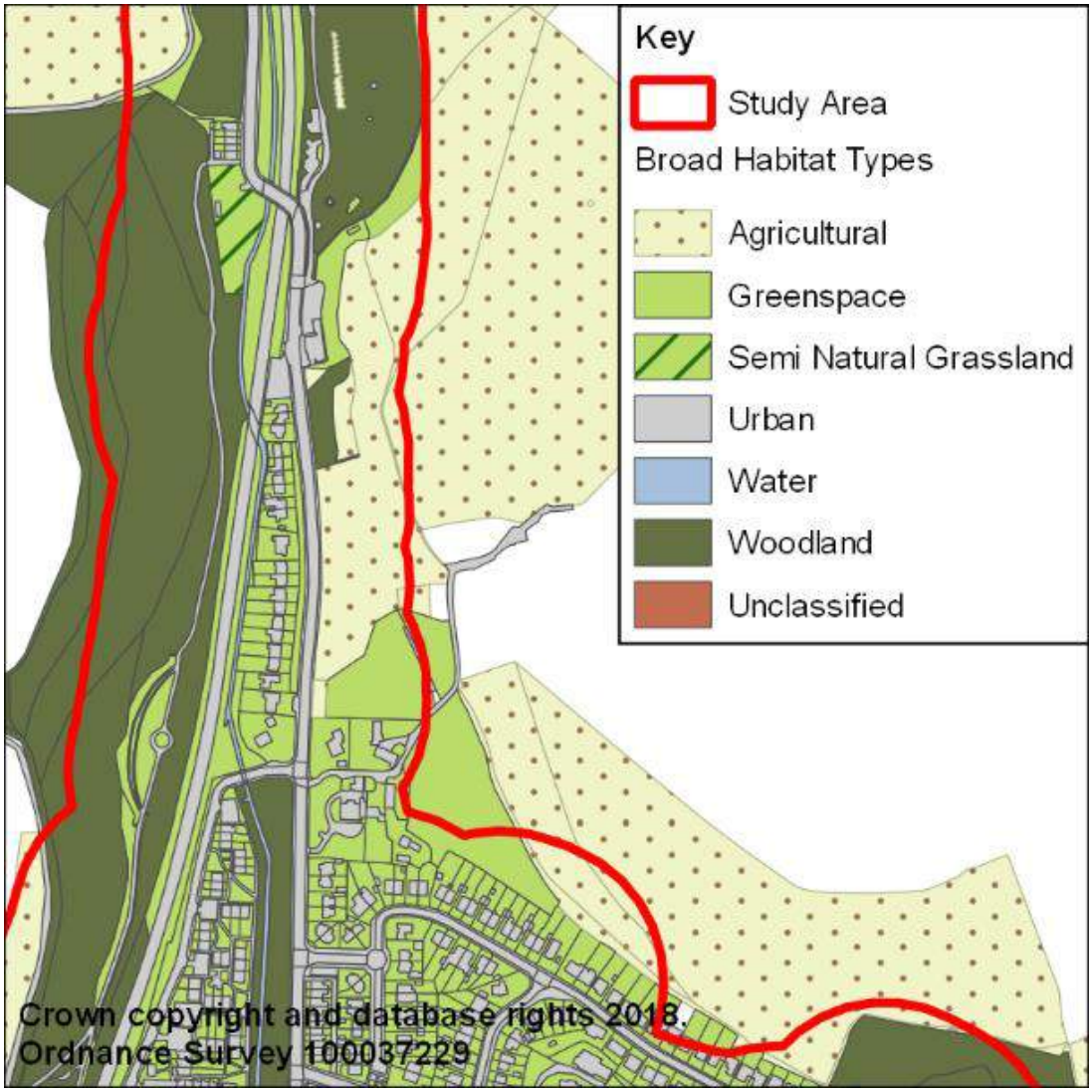


Figure 4: Example of Broad Habitat Mapping

Stage 3: ESS in Scope

3.12 Table 1 lists the ESS delivered or supported by waterbodies in the study area. A detailed literature review and analysis of how each ESS can be measured and/or valued and an explanation as to why some ESS are not subject to valuation is provided in Appendix D. This is usually because:

- There is currently no robust or widely-agreed economic method for quantification of the benefit flows; and
- The value of the ESS is insignificant or irrelevant to the scope of this project which focuses on urban waterbodies.

3.13 Appendix E describes how ESS opportunity maps are compiled. Where lack of data or research prevents ESS mapping, a narrative account of opportunity is provided. The narrative provides an overview of the general opportunities and interventions appropriate to the ESS.

Table 1: ESS in Scope

Service	Natural Capital Valuation	ESS Opportunity Assessment Map
Water quality	Yes	Yes
Water resources	Yes	Narrative
Flood risk mitigation	Yes	Yes
Amenity	Yes	Yes
Carbon sequestration	Yes	Yes
Mental health	Yes	Yes*
Physical health	Yes	Yes*
Leisure and recreation	Yes	Yes
Biodiversity and ecological networks	No	Yes
Agriculture (food production)	Yes	Narrative
Timber production	Yes	Narrative
Pollination	No	No
Air quality	No	Yes
Noise reduction	No	Narrative
Temperature regulation	No	Narrative

**Using leisure and recreation maps*

Stage 4: Natural Capital Account

3.14 The Natural Capital Account displays monetary estimates of value from the ESS shown in Table 1. The valuation of each service proceeds in two general steps.

3.15 Firstly, the physical quantity of the ESS provided is estimated. This quantity can be expressed as tangible products, such as food or timber, or can be quantified in terms of the beneficial effect that the area's natural capital has on its population, such as better health.

3.16 Secondly, each ESS is translated into monetary terms according to its contribution to the economy. For instance, food and timber can be expressed in terms of revenue earned from these products. Other ESS, such as health, can be valued according to the contribution that improved health outcomes of a population have on the economy. A brief description of the methodology used to estimate and value each ESS is contained in the main report. The detailed methodology is provided in Appendix D.

3.17 The total value of ESS in the IMC and the contribution of each ESS individually are summarised in a Natural Capital Account. This is used to show the annual value of services as well as the value of ESS over a period of 30 years. This time period is consistent with HM Treasury Green Book guidelines on discounting future costs and benefits, where periods up to 30 years are considered standard appraisal horizons.

3.18 The approach to natural capital valuation pursued in this study is to estimate the level of ESS at the most disaggregated unit possible. This means that the value of ESS can be accurately mapped and also reported at scales useful to stakeholders, such as for each of the 28 waterbodies that make up the IMC.

3.19 In some cases, the calculation of ESS is dependent on the characteristics of the local population, such as the number of residents or house prices. Data on these characteristics are reported at the MSOAs, which can extend beyond the 100m buffer study area. Accordingly, ESS values are reported for all MSOAs that overlap with the 100m buffer in order to incorporate this information.

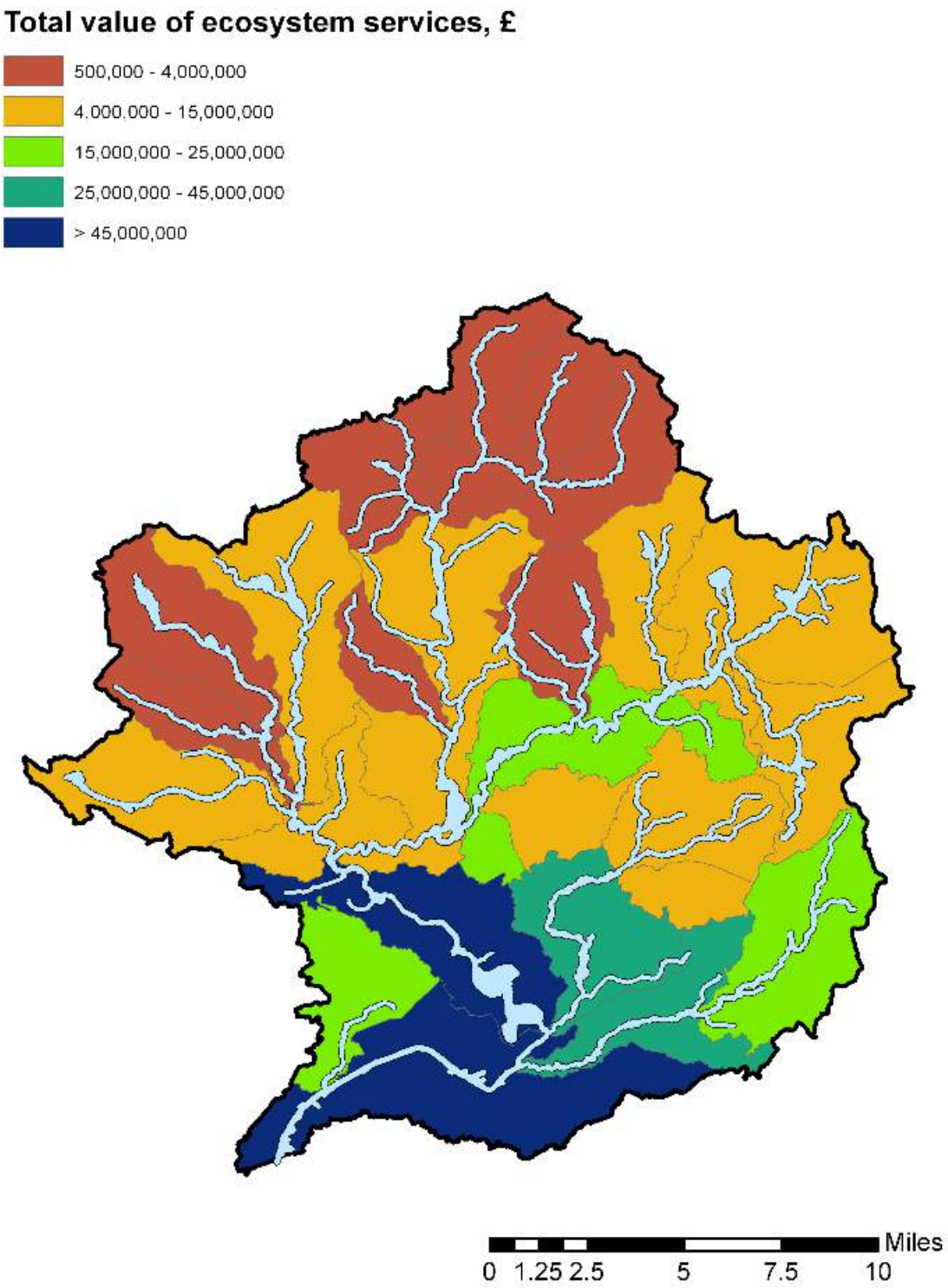


Figure 5: Total Value of Ecosystem Services by Waterbody Catchment. Natural capital accounts are estimated at the MSOA level to accurately assess ESS value. The total natural capital values are displayed for each waterbody catchment (above) to provide a strategic overview.

Stage 5: ESS Opportunity Assessment

3.20 An ESS opportunity arises on land which, given its physical, social, economic, geographical and cultural characteristics, offers potential to intervene and improve ESS functioning and thus uplift natural capital value. An opportunity arises where there is a combination of feasibility and need. Where there is opportunity, this can usually be mapped by land parcel for each ESS individually. In some cases, an opportunity cannot be mapped at such a granular level, but can be assessed in a narrative manner.

3.21 The opportunity assessment for each ESS is made up of several 'attributes' which analyse different aspects of each service and are scored. For example, water quality ESS is made up of an assessment of attributes including; land connectivity, hydrological connectivity, slope, soil characteristics, land use and consented discharge locations. The combination of the scores from the ESS attributes provides the overall score for the service.

3.22 Funders, policy-makers, project developers, members of the Irwell Catchment Partnership and infrastructure planners can use the ESS Opportunity Assessment to support and inform their decisions on protection of the natural environment and investment in waterbody projects. Decision-makers can consider which interventions are appropriate in terms of their priorities (as described at Stages 6 and 7 below). Figure 6 shows how the concept of ESS Opportunity Assessment informs Natural Course decision-making.

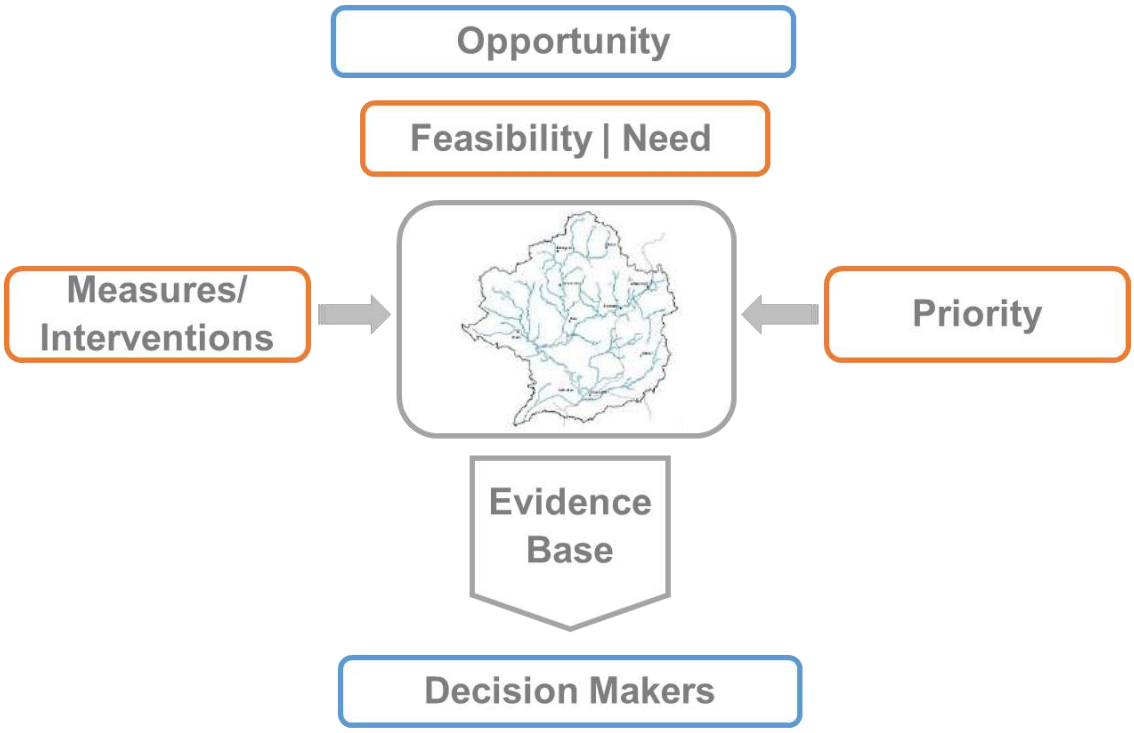


Figure 6: Opportunity Mapping and the Decision Making Process

3.23 The detailed process of ESS Opportunity Assessment builds on best practice from various sources, as listed at Appendix E. The process is illustrated at Figure 7.

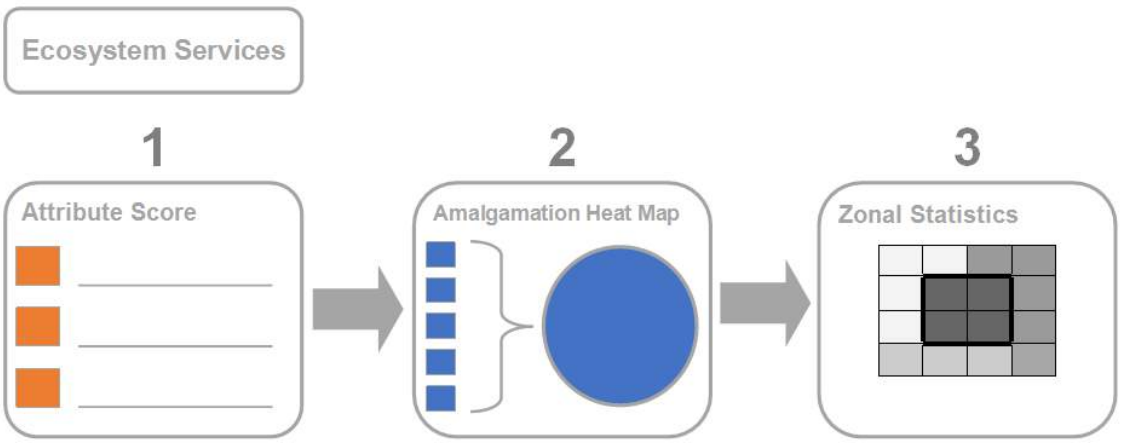


Figure 7: Process of ESS Opportunity Assessment

3.24 Opportunity scores may be binary (1 = opportunity, 0 = no opportunity) or may be scaled in relation to the level of need or the depth of the opportunity (for ecological networks ESS, greenspace adjacent to ecological designations score 2, whereas greenspace adjacent to Section 41 habitats or a local designation score 1).

3.25 Heat maps are produced for each ESS and for combinations of ESS (see Figures 8 and 9). These show land parcels where there are opportunities to improve multiple ESS through interventions. The Mapping Tool User Guide (Appendix F) describes how the interactive maps (hosted on MappingGM) should be used. Limitations arising from currently-available datasets is documented within the Opportunity Assessment – Methods and Mapping Protocols (Appendix E).

3.26 All ESS heat maps display the total ESS score, the lower the banding the lower the potential opportunity score.

3.27 Zonal statistics are then used to identify waterbodies with the relatively greatest degree of opportunity which could help with prioritisation of Natural Course projects.

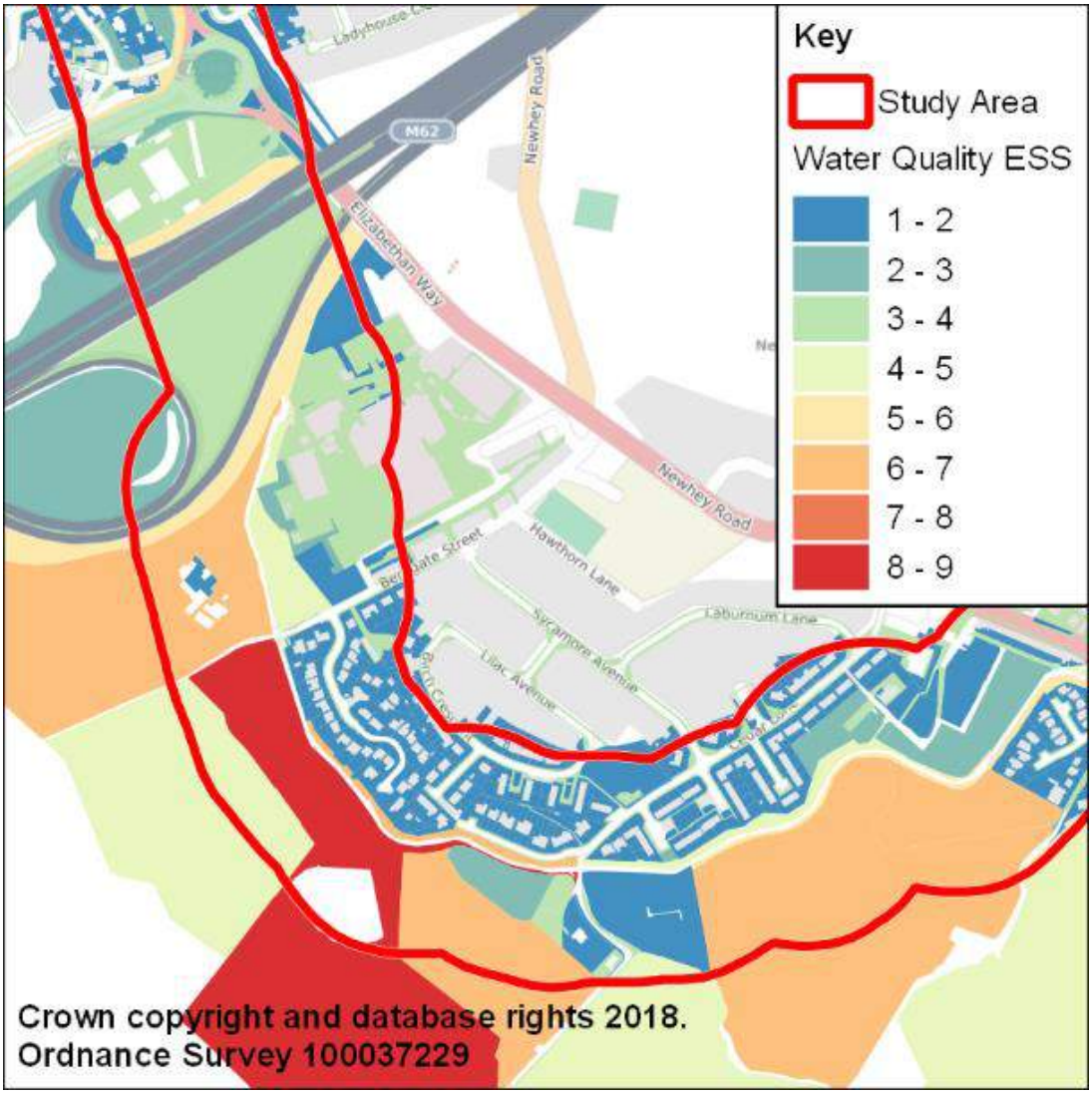


Figure 8: Heat Map of a Waterbody Corridor Showing a Single ESS Opportunity Assessment (Water Quality)

3.28 Appendix E details all the scores, attributes and limitations applicable for each ESS. Some ESS opportunities cannot be mapped at the fine-grained scale of the study area, but nevertheless they are described in narrative form.

3.29 There is no ESS opportunity where:

- There is no need for ESS uplift e.g. there is no need to improve leisure and recreation ESS where there is no community within walking distance;
- The land parcel is already in favourable condition for the ESS;
- The land parcel does not lend itself to intervention in question e.g. one would not normally create Sustainable Drainage Systems (SUDS) in a cemetery. We have called these "excluded" land parcels; or

- The intervention will not feasibly result in ESS improvements e.g. land that is not hydrologically connected to the waterbody will not deliver water quality ESS benefits.

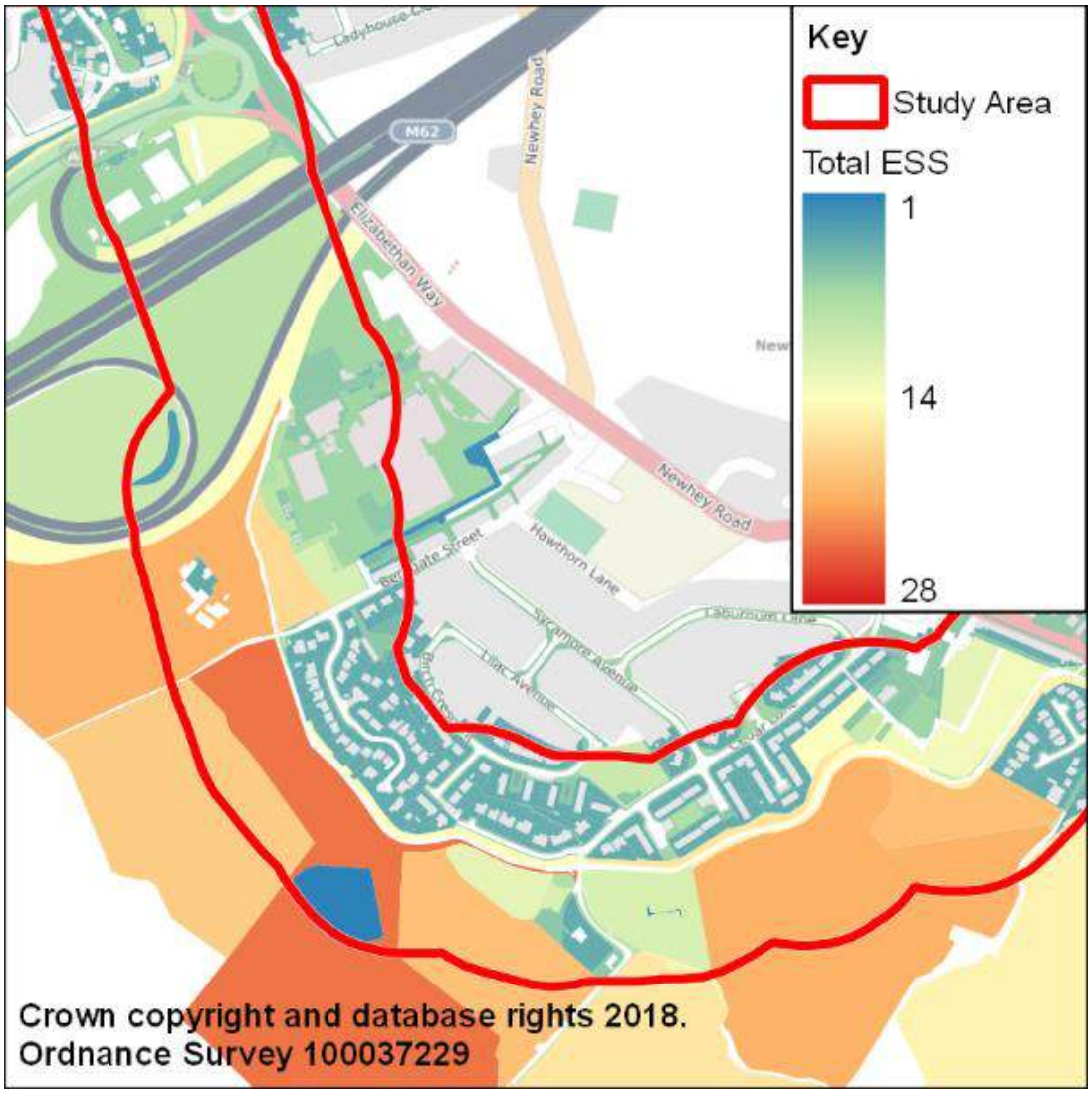


Figure 9: Composite Heat Map of a Waterbody Corridor for all ESS Opportunities Combined

3.30 During the development of the habitat mapping, ESS valuations and opportunity mapping, some limitations became apparent, primarily related to constraints on data availability, as described below:

- **2m LIDAR Digital Terrain Model:**
  Some land within the IMC does not have fully detailed LIDAR coverage. This limitation is difficult to work around without reducing the accuracy of analysis in areas that have LIDAR coverage. The Environment Agency (EA) recently committed to having full UK coverage by 2020[9].
- **OS MasterMap Greenspace / OS Open Greenspace:**
  The OS Greenspace line of products are designed only to cover urban areas[10]. The IMC extends into rural areas where identifying Greenspace and assigning a habitat typology requires manual classification which is time inefficient.

[9] https://environmentagency.blog.gov.uk/2017/12/30/uncovering-englands-landscape-by-2020/
[10] https://www.ordnancesurvey.co.uk/docs/product-guides/osmm-greenspace-product-guide.pdf

- **OS MasterMap:**
  Some parcels of MasterMap do not have classifications, and so cannot be assigned a habitat type unless additional data is available through ground-truthing or local knowledge. This usually occurs where land is in transition (including in this case, the creation of an urban flood drainage basin in Salford which was undergoing engineering works at the time of the relevant Mastermap survey). In the study area, there are 124 hectares of unclassified parcels (0.74% of the total classified habitat types). Given these potential issues with MasterMap it is important to highlight the significance of local knowledge, and how this combined with the MasterMap data provides the most in depth analysis.
- **Soils Data:**
  Analysis based on soils data has been compiled using the freely available European Soil Database v2.0. Higher resolution data is available at an approximate cost of £4,000 for the IMC which was beyond the scope of this project. Accurate analysis of soils and related ESS opportunity will require detailed local assessment of the soil type and condition in a particular location.
- **GM Cycle Routes/ Sustrans:**
  Some discrepancies exist between the data provided by Sustrans and the data made available by Transport for Greater Manchester, typically relating to city centre routes that are not present in the data provided by Sustrans.
- **Greater Manchester Tree Audit (City of Trees):**
  The Greater Manchester Tree Audit completed by City of Trees provides approximate tree locations and crown spread. The data is limited to Greater Manchester and does not cover the Lancashire parts of the study area.

Stage 6: Measures

3.31 For each ESS, there may be several types of interventions (or "measures"), likewise, several types of measures can deliver ESS opportunities (see Table 2). For example, the River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 proposes numerous projects which align with the Irwell Catchment Partnership's key objectives, which are:

- Cleaner water (projects to improve water quality);
- Better functioning and resilient waterbodies (projects which address WFD mitigation measure actions, physical modifications); and
- Natural habitats (habitat creation/ improvement projects).

3.32 Single measures may enhance multiple ESS – tree-planting is an example where water quality, amenity, carbon sequestration ESS are all enhanced. In other cases, multiple measures may be needed to enhance multiple ESS e.g. improving access, creating a reedbed, removing litter, planting trees. The table below provides some example measures which could be implemented.

Table 2: Measures to Deliver Ecosystem Service Uplift

Measure	Example	ESS Enhanced
Channel Re-naturalisation	• Remove obstructions and weirs • Create fish-passes • Bank re-naturalisation • Full waterbody restoration	• Water quality • Flood risk mitigation • Biodiversity and ecological networks

Measure	Example	ESS Enhanced
Floodplain Re-naturalisation	• Create washlands • Realign flood berms to increase storage capacity. • Re-grading of adjacent land to water bodies	• Water quality • Flood risk mitigation • Biodiversity and ecological networks • Carbon sequestration
Diffuse Pollution Attenuation Schemes	• Plant wet woodlands and reedbeds along hydrological flowpaths linked to the waterbody • Create or manage roughened vegetation strips alongside waterbodies and tributaries where they pass through farmland or managed greenspace	• Water quality • Biodiversity and ecological networks • Carbon Sequestration • Amenity
Pollution Source Control Schemes	• Phosphate stripping schemes at Wastewater Treatment Works (WwTW), • Install interceptors in industrial estate and Combined Sewer Overflow's (CSO), plant designed reedbeds for leachate control, at known problem sites • Create SUDS on industrial estates and highway discharge points	• Water quality • Water resources • Biodiversity and ecological networks
New Waterfront Access	• Create and enhance footpath/cycleways on land associated with the waterbodies. • Green Commuter Routes. • Nature Trails • Create or improve signage • Connecting existing route to expand total travel distance possible.	• Leisure and recreation • Amenity • Mental health • Physical health • Air quality
Community Stewardship	• Friends of groups • Litter-picks • Adopt-a-river schemes • Volunteering days • School / Child sports days	• Water quality • Mental health • Physical health • Biodiversity and ecological networks

Measure	Example	ESS Enhanced
Health and Cohesion Schemes	• Green gyms • Walking for health prescriptions • Forest schools	• Mental health • Physical health
Urban Greening	• Street trees • Green roofs and walls • Raingardens	• Water quality • Flood risk mitigation • Biodiversity and ecological networks • Amenity • Carbon sequestration • Temperature regulation • Air quality
Habitat Creation	• Woodland planting • Arable reversion • Reedbeds, ditches and ponds • Habitat creation • Land management techniques to improve soil structure • Extension of environmentally important areas or designations	• Water quality • Flood risk mitigation • Biodiversity and ecological networks • Amenity • Carbon sequestration • Air quality
Natural Flood Management	• Leaky dams • Buffer strips • Land use change • Creation of and use of run off attenuation features	• Flood risk mitigation • Biodiversity and ecological networks • Carbon sequestration

Stage 7: Prioritisation

3.33 Opportunity mapping has implicit prioritisation. For example an asset which scores highly for a number of opportunities associated with one ESS self-identifies as meriting prioritisation. An asset which scores highly across several ESS merits further consideration when prioritising activity.

3.34 However, other factors must also be considered when formulating an investment portfolio. These factors come under the following categories:

- **Legal and Policy Push:**
  Is the project directly needed to meet statutory, legal or policy objectives? e.g. WFD, River Basin Management Plans (RBMP), Natural Environment Rural Communities (NERC) Act 2006, Safeguard Zones, Source Protection Zones, Drinking Water Protection Zones, communities at risk from flooding, GMSF Strategic Sites, Nature Improvement Areas, Climate Change Action Plan, Health and Wellbeing drivers.
- **Addressing Pinch-points:**
  Does the project indirectly address a pinch-point or bottleneck associated with the above priorities?

- **Effectiveness:**
  Is the project likely to significantly uplift natural capital?
- **Equity:**
  Will the project benefit a deprived community (most deprived 20% in Indices of Multiple Deprivation (IMD))?
- **Synergies:**
  Can the project add value to existing schemes that enhance ESS, or accelerate delivery of proposed schemes? For example, the River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 has a comprehensive database of planned and possible projects that address WFD and other drivers.

3.35 Project prioritisation for a Natural Course investment portfolio is beyond the scope of this study, but the narrative account for each ESS in subsequent chapters of this report includes a preliminary appraisal of spatial priorities that emerge from the ecosystem valuation and opportunity maps.

Stage 8: Stakeholder Involvement

3.36 An aspiration of this project is to trigger an understanding and interest in the natural capital provided by the IMC and then mobilise funds to implement interventions. With this in mind, it has been important to engage with key partners and stakeholders during the study to inform and test the methodology to ensure it is robust, realistic and credible.

3.37 Stakeholders have also provided a wealth of information and data which has been utilised to ensure the datasets used are as extensive and up-to-date as possible. Appendix B provides a summary of two stakeholder workshops held during this study, including comments from stakeholders about project priorities.

3.38 MappingGM will host the ESS opportunity heat maps and the underlying habitat mapping, which will enable stakeholders and community groups to explore and test their own ideas for projects which benefit the water environment and communities alongside the waterbodies. The ESS opportunity mapping data layer will be linked to the Irwell Catchment Partnership's story map.

Stage 9: Investment Portfolio

3.39 The production of a portfolio of Natural Course projects is beyond the scope of this study. Nevertheless this study provides valuable evidence about the natural capital value of the waterbodies in their present condition, and the range and depth of opportunities to enhance the ESS flowing from the waterbodies.

3.40 This study sits alongside the other studies previously commissioned by Natural Course (see Chapter 2) which provide information on measures that can address WFD and flood risk problems. As the IMC Partnership and other key stakeholders develop an investment portfolio, they can:

- Examine the baseline Natural Capital Account for the waterbody in question – this will identify the current drivers of natural capital value and (by comparison to other waterbodies), identify where uplifts in natural capital value are likely; and
- Examine the ESS opportunities mapping to identify whether the proposed project would be likely deliver significant ESS, and whether the project design could be

refined to deliver additional ESS not previously considered and draw in other beneficiaries and funders who have a mutual interest.

3.41 The final chapter of this report considers the next steps towards the development of an investment portfolio.

4.0 Study Area Overview

> The overall area of the IMC is 78,452ha. The study area for the project was agreed with the Natural Course Project Steering Group and is 16,676ha (i.e. waterbodies, floodplains and 100m buffer) which is 12% of the overall IMC. The length of waterbodies in IMC total 464 km in length. Of the 464 km, 372km (77%) are designated as Heavily Modified by the Environment Agency.

4.1 The IMC contains 28 waterbodies focussed around the Rivers Irk, Roch, Medlock, Irwell and Croal. 26 of these waterbodies are HMWB. The two waterbodies which are not HMWB are Whittle Brook (Irwell) and Wince Brook.

4.2 Table 3 gives a breakdown of the broad habitat types and sub-habitat types in the study area. As explained in Chapter 3, the study area for this project is focussed on the waterbodies, their flood zones and a 100m buffer.

Table 3: Breakdown of Habitat Types in the Study Area

Broad Habitat Type	Area (ha)	Habitat Sub-Type	Area (ha)
Agricultural	**5,127**	-	-
Greenspace	**4,142**	*Amenity*	*1447*
		Private Garden	*608*
		Unknown	*606*
		Transport	*535*
		Sports Facilities	*481*
		Park	*299*
		Institutional/ Educational Grounds	*87*
		Religious Grounds	*58*
		Allotments	*21*
Urban	**2,933**	*Hardstanding*	*816*
		Road	*685*
		Roadside/ Footpaths	*408*
		Residential	*283*
		Buildings	*260*
		Industrial/ Commercial	*225*
		Unknown	*168*
		Railway	*87*
Woodland	**2,508**	*Non-coniferous*	*2,265*
		Non-coniferous Ancient	*134*
		Coniferous	*109*
Water	**1,025**	*River*	*902*
		Pond/ Lake/ Reservoir	*57*
		Canal	*32*
		Unknown	*20*
		Marsh or Saltmarsh	*13*
Semi-natural Grassland	**818**	-	-
Unclassified	**124**	-	-
Total Area	**16,676**		

4.3 The habitat typology forms the basis of ESS opportunity scoring, as described at Appendix C and E. Water habitat types are not subject to ESS scoring, since they evidently cannot be subject to measures such as tree-planting, access creation etc. However, ESS measures for the waterbodies are mapped in the River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 Water Body Output Maps.

4.4 Land that is “unclassified” by Ordnance Survey is usually in the process of transition, and cannot be scored.

4.5 Habitat types in the “unknown” category are scored but may be unable to achieve the maximum potential score where an attribute is based on the land classification. An example of where unclassified parcels achieve scores, is within the air quality ESS opportunity mapping whereby the habitat type does not affect the base data (modelled background pollution data). Appendix C describes how issues associated with “unknown” categories are overcome in terms of ESS scoring.

5.0 Natural Capital Account

> The Natural Capital Account for the IMC in Table 4 shows the economic value of services provided by the natural capital contained in the study area.

5.1 Values are reported separately for each ESS. Both the annual value of services is reported, as well as the value of these services over a 30 year time period. The values correspond to the 100m buffer study boundary and overlapping MSOAs.

5.2 Economic value is calculated by first estimating the level of each ESS currently provided and secondly by estimating the monetary value that people place on this ESS. Each of these calculations is based on accepted methods for valuing each of these services and the methodology and data sources are provided in Appendix D. The methodologies applied in this study represent best practice approaches and are recognised as the currently most accurate methods of determining values. A thorough review of the literature was undertaken to utilise methods that were most applicable to the IMC. Local environmental and demographic data is also used to model specific attributes of the catchment and its population.

5.3 The monetary valuation of each service is modelled as the value currently provided by natural capital. The valuations are based on a range of methods that value people's enjoyment and benefits of using of these assets (such as recreation and health), the role the assets play in the local economy (such as water use and agriculture) and global benefits (such as carbon). Each of these is displayed in a common monetary metric in order to assess the relative contribution of each of the services provided by natural capital.

Table 4: Natural Capital Account for the IMC

Service	Annual Value (£m)	Capital Value* (£bn)	Share (%)
Assets			
Leisure and recreation	190	3.5	41%
Physical health	98	1.8	21%
Amenity	80	1.4	17%
Mental health	59	1.0	13%
Water resources	23	0.4	5%
Water quality	14	0.3	3%
Carbon sequestration	1	<0.1	<1%
Agriculture (food production)	<1	<0.1	<1%
Timber production	<1	<0.1	<1%
Gross Value	465	8.5	100%

Service	Annual Value (£m)	Capital Value* (£bn)	Share (%)
Assets			
Liabilities			
Flood Risk	(48)	(0.9)	
Net Value	**418**	**7.7**	

** Capital value refers to the present value of the annual services evaluated over a 30 year time period. These annual flows are discounted at a rate of 3.5%.*

5.4 The annual value of services provided by natural capital in the study area is estimated to be worth a net value of £418 million. This reflects the contribution of a diverse range of ESS provided by habitats in the IMC, including green spaces and waterbodies. The account also demonstrates that most ESS provided by the IMC are derived from assets since they are economically beneficial. Flood risk is shown as a reduction given that it represents a significant cost to people living around the IMC, with expected annual damage to residential property estimated to be £48 million.

5.5 Leisure and recreation is the most valuable ESS provided by natural capital in the study area, with an annual value of £190 million. At around 40 per cent, this value makes up a large share of the total value and highlights the importance of habitats in the IMC as spaces for enjoyment and use by the IMC's residents.

5.6 The physical and mental health benefits of natural capital also make up around one-third of the total value. This means that households, the public sectors and businesses avoid around £157 million per year in health costs due to the existence of green spaces around the IMC.

5.7 The waterbodies themselves are also integral to the local economy owing to their use in supplying public drinking water and sanitation, the production of energy, for industrial and commercial purposes. The availability of water is worth over £20 million per year.

5.8 The diverse set of habitats in the IMC is reflected in the value of carbon sequestration provided by woodlands and the revenue that forest owners derive from selling timber. A significant share of land in the IMC is agricultural and is primarily used for grazing land and is also reflected as an asset in the account.

5.9 Appendix G contains the Natural Capital Accounts by Waterbody and District.

6.0 Water Quality

Value of the ESS in the Study Area

6.1 Stretches of waterbodies that are clean are enjoyed more by people who live near to and visit these areas, as has been revealed in studies that show people value improvements in water quality much more in their local area compared with improvements regionally or nationally[11]. The value that people place on their enjoyment of waterbodies of higher quality is estimated in terms of the leisure and recreation, amenity, and non-use values attached to the waterbodies in the IMC.

6.2 It is estimated that people place a value of £14 million per annum on the 464km (292 miles) of water in the IMC being classified as 'Good' according the WFD Ecological Potential.

6.3 This value reflects monetary preferences of residents in England and Wales for achieving broad water quality improvements that would meet both ecological and chemical guidelines set under the WFD. These values represent preferences for a set of attributes related to water quality and are not likely to reflect highly localised water quality issues. These valuation issues are outlined in Metcalfe et al. (2012)[12].

Table 5: Total Value of ESS within the Study Area

Variable	Value
Length of waterbodies within the IMC (km)	464
ESS Value	£14 million

6.4 The Environment Agency's National Water Environment Benefit (NWEB) values include IMC specific values (per km). Values have been uprated to 2017 prices for accuracy and have been applied in Table 5.

6.5 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

[11] Metcalfe, P. et al. (2012) An assessment of the nonmarket benefits of the Water Framework Directive for households in England and Wales. Water Resources Research, 48, W03526.
[12] Metcalfe, P. et al. (2012) An assessment of the nonmarket benefits of the Water Framework Directive for households in England and Wales. Water Resources Research, 48, W03526.

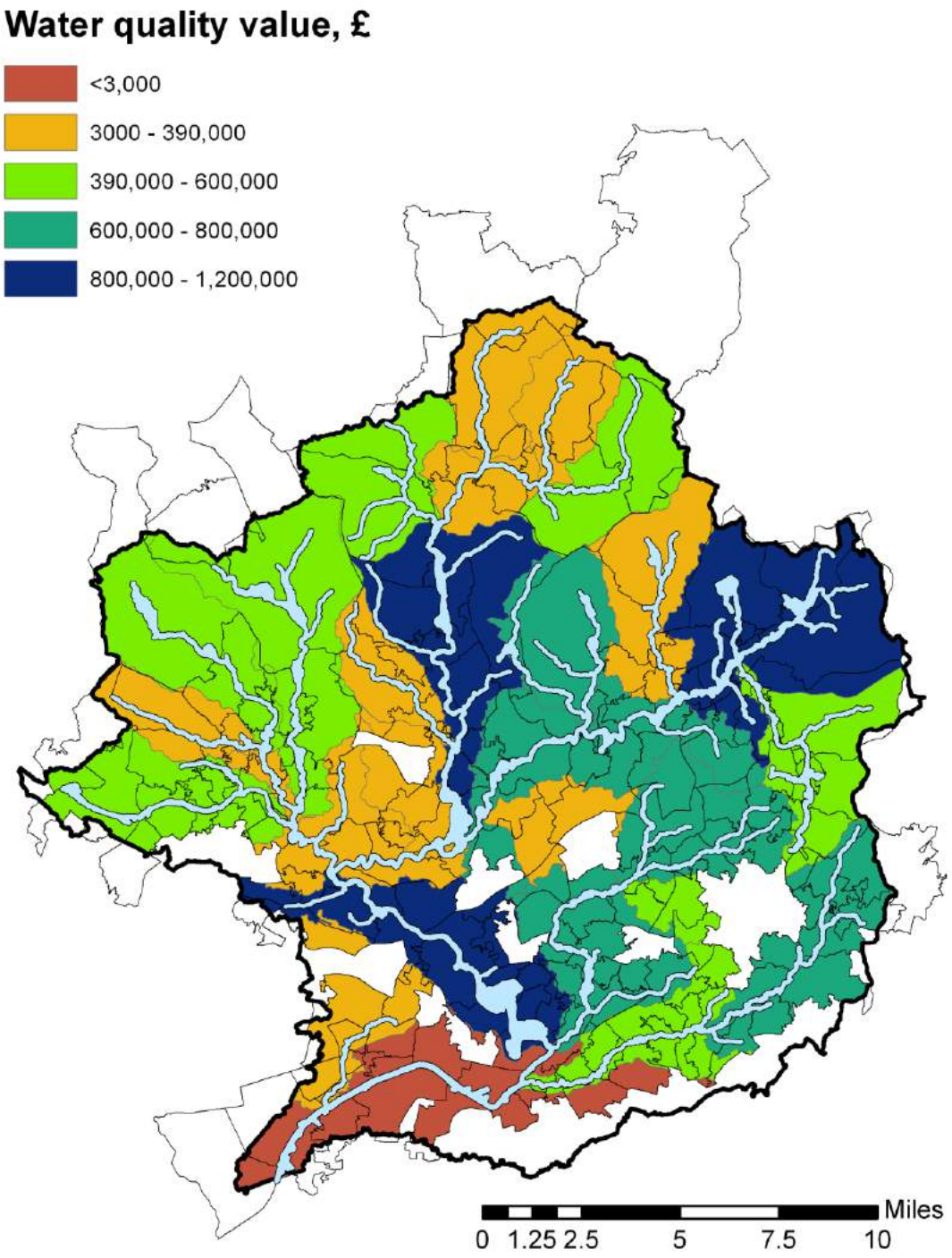


Figure 10: Value of Water Quality within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor and 1 in 100 year flood zone)

Issues

6.6 The River Irwell Management Catchment – Evidence & Measures, Final Report February 2017[13]provides information on water quality issues, concluding with waterbody output maps which indicate priority projects the Irwell Catchment Partnership can promote to address water quality problems.

6.7 Whilst a decline in industrial activities and improvements in sewage treatment processes have led to significant water quality improvements, the IMC continues to suffer from poor water quality. Most of the waterbodies have at least one water quality element as a reason for not achieving good status (RFNAGS) under the WFD.

6.8 Of the 28 waterbodies within the IMC, none are currently classed as "Good" in respect of WFD Ecological Potential, 27 are classed as "Moderate" and 1 as "Poor".

6.9 Water quality RFNAGS (see Figure 11) are generally due to a mix of point and diffuse source pollution problems. Point sources are mostly due to water company issues, but industrial, trade, highways and domestic discharges are also problematic.

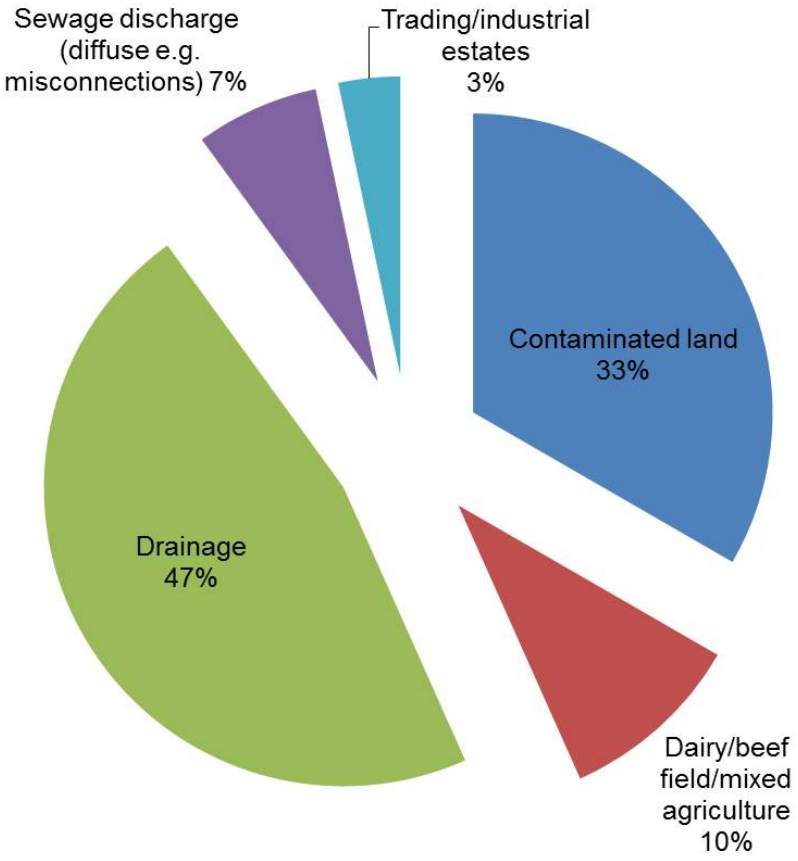


Figure 11: Activities Contributing to Diffuse Pollution Sources (APEM, 2017)

6.10 General surface water drainage to waterbodies (housing, mixed, road run-off, landfill leachate) causes most of the diffuse pollution. Contaminated land is also a large contributor, with some diffuse source problems arising from agriculture, sewage misconnections and industrial estates.

[13] River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 for Greater Manchester Combined Authority

Opportunity Assessment

6.11 ESS opportunities to address water quality problems arise on land where it is feasible to implement natural environment measures which:

- Filter diffuse source pollutants before they reach waterbodies;
- Filter or slow sediment-laden surface water flows before they reach waterbodies;
- Reduce the probability or quantity of soil erosion or overland flows of sediment; and
- Convert land uses to types where soil has a greater capacity to store water or absorb/stabilise pollutants.

6.12 ESS opportunities also arise where there is a need for water quality improvement. Need in this case is defined by the presence of consented discharge points which could, theoretically at least, be subject to interventions to rationalise or remodel outfall points to enable filtering or interception of discharges prior to entering the waterbodies

6.13 ESS opportunities for water quality improvement are scored in terms of the attributes listed at Table 6. A detailed narrative is provided at Appendix E.

Table 6: Ecosystem Service Opportunity Assessment for Water Quality

Attribute	Score	Rationale
Connectivity to waterbody	Land parcels physically connected to the WFD waterbody score 1	These parcels offer opportunities for creation of naturalistic buffer strips, vegetation roughening which capture and filter sediment and pollution. These parcels have greatest opportunity for litter-picking
Hydrological connectivity	Surface water flow paths score 1	Flowpaths and areas where water might pool offer opportunities for wetland creation and establishment of wet woodland and reedbeds which capture and filter sediment and pollution
Slope	Land which slopes towards a WFD waterbody at >7 degrees scores 2, land that slopes between 5 and 7 degrees scores 1	Steeply sloping land is at greater risk of erosion and hence sediment-laden flows

Attribute	Score	Rationale
Soil characteristic	Soil types whose texture, wetness or structure make them prone to rapid run-off and/or leaching are scored 1 or 2	Soil factors are indicators of whether a given soil type is capable or not of regulating water quality. For this study, sufficiently fine-grained soil data was not available within budget to apply to the IMC as a whole
Land Use	Arable or regularly tilled land scores 2, permanent grassland (such as grazed land or urban greenspace) scores 1. Woodland scores 0	As woodland is considered to be the land use least likely to generate, and most likely to absorb, pollutants and sediments, the scoring system is based on the number of steps from the current land use to woodland
Consented discharge points	Land parcels with consented discharges score 1	There may be opportunity to intervene to remodel the discharge point or install filter beds of natural vegetation

6.14 ESS water quality opportunities are mostly mapped by land parcel. For example Figure 12 shows the consented discharge point's map.

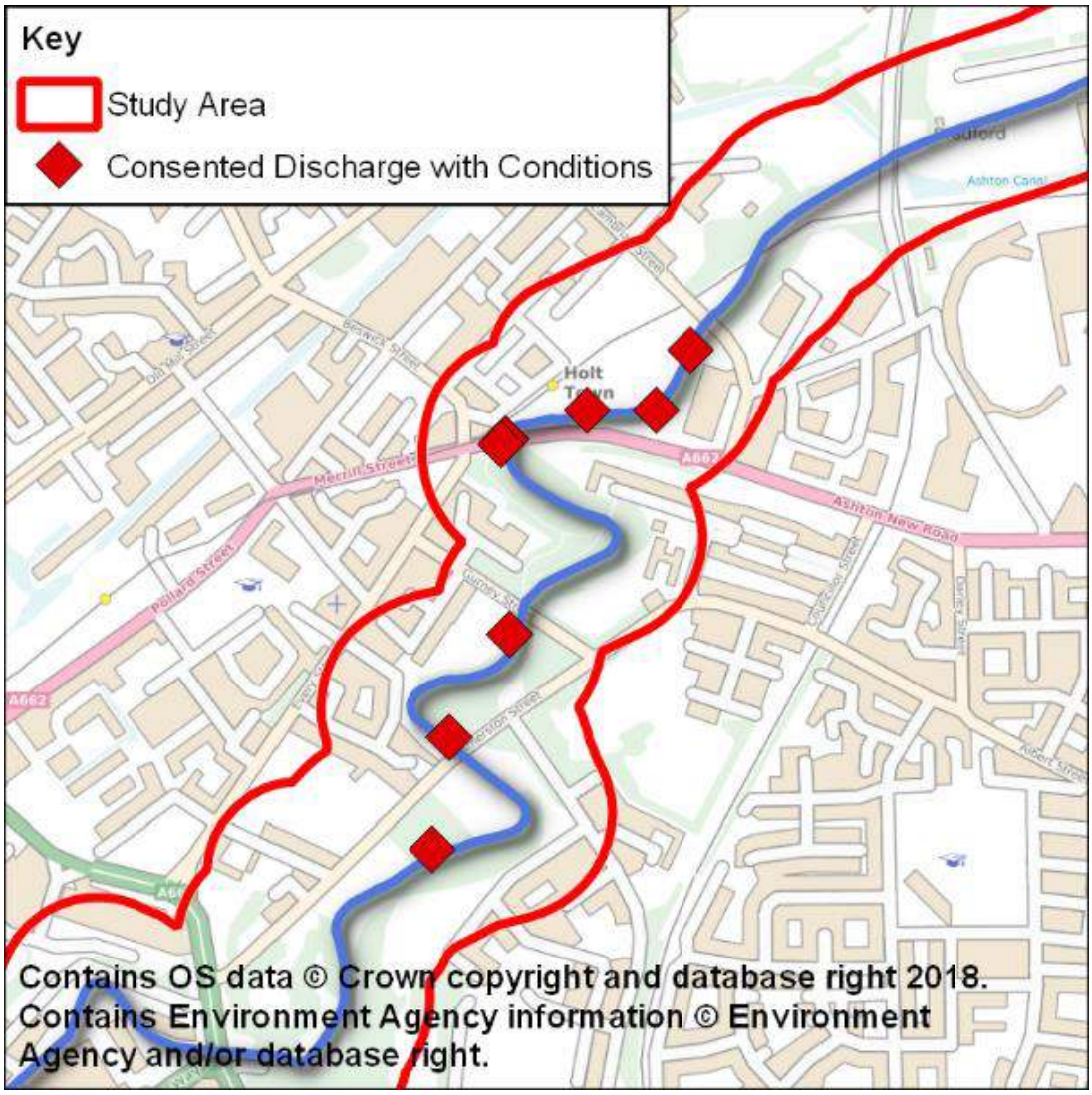


Figure 12: Consented Discharge with Conditions

6.15 Flowpaths are mapped at a fine-grained scale, for example Figure 13 shows land with a high concentration of flowpaths. This is considered to be one of the most important innovations of this project, given the complex geospatial GIS and terrain analysis. It is applicable to all urban catchments given the LIDAR resolution[14] now available.

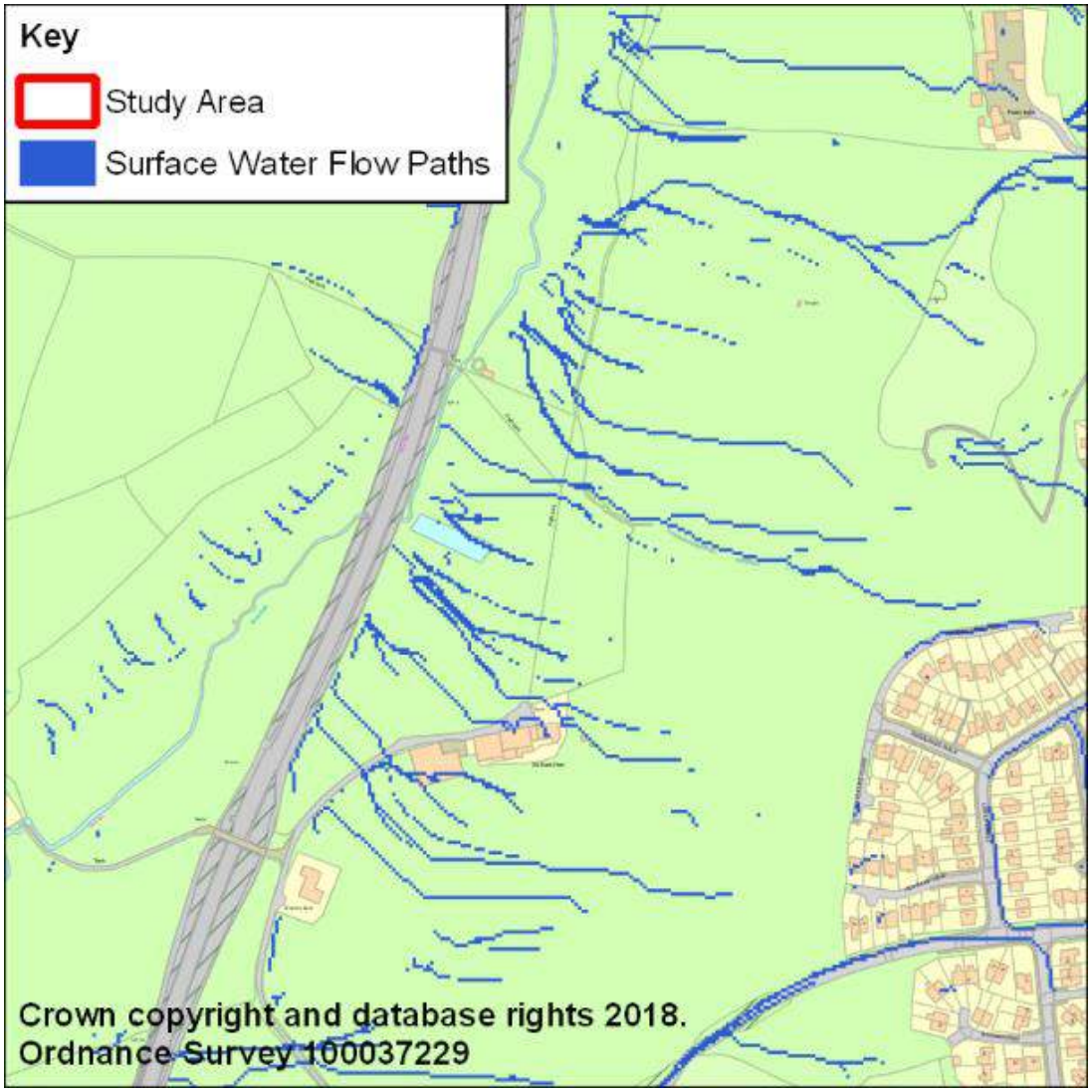


Figure 13: Land with a High Concentration of Flowpaths

6.16 A water quality ESS opportunity heat map is generated (see Figure 14).

[14] http://environment.data.gov.uk/ds/survey/#/survey

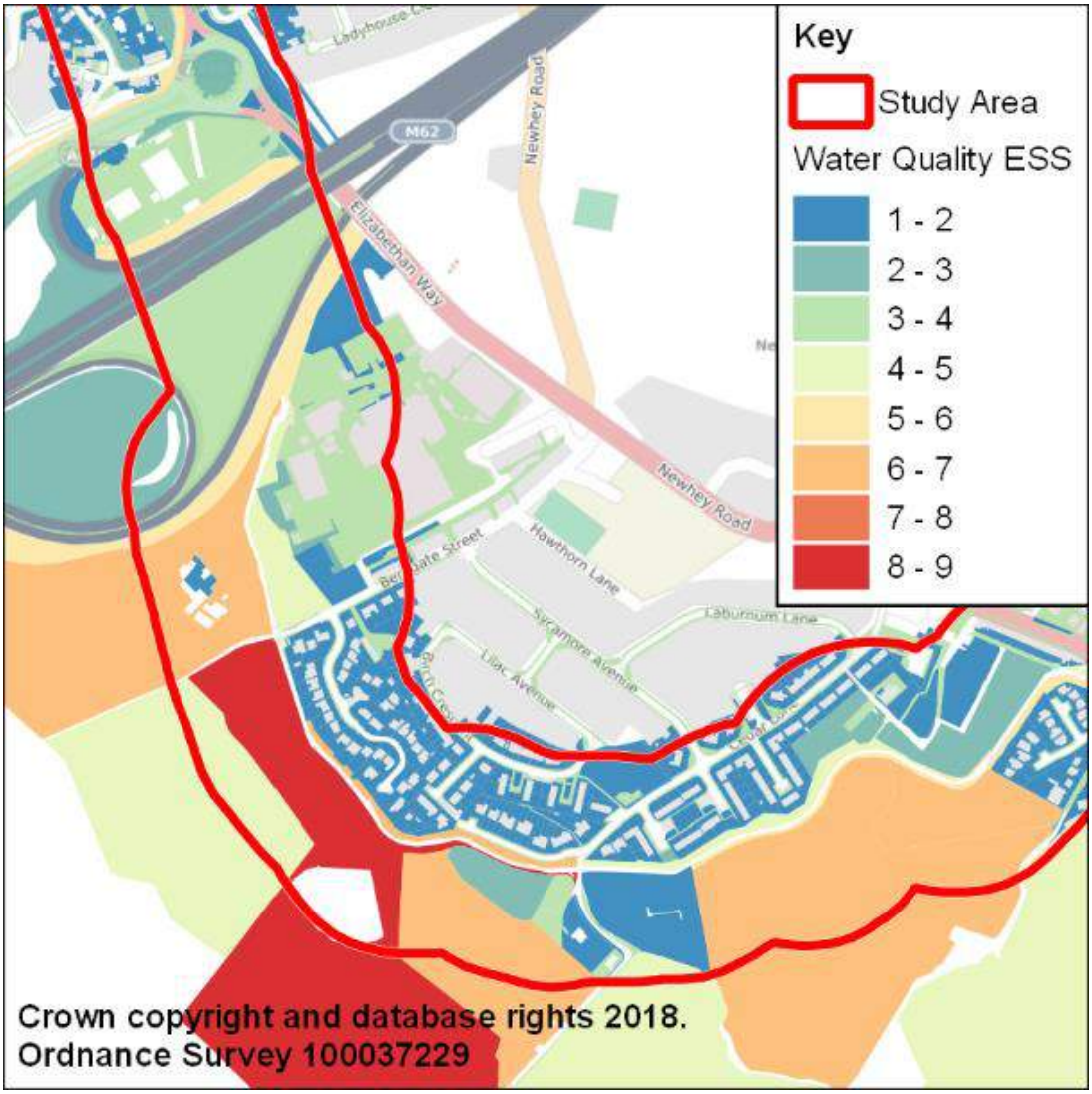


Figure 14: Water Quality ESS Opportunity Heat Map

Priority Interventions

6.17 Stakeholder interventions to improve water quality ESS will be of priority in the following scenarios:

- Waterbodies shown with above average ESS opportunity for water quality[15] in Appendix H
- Waterbodies of High[16] and Medium[17] Priority, as shown in River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 Water Body Output Maps;
- Opportunities identified through the Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments[18] and subsequent consultations;

[15] Bradshaw Brook, Eagley Brook, Irwell (Cowpe Bk to Rossendale BTW), Irwell (source to Whitewell Brook), Irwell/Ship Canal, Kirklees Brook, Limy Water, Medlock (Lumb Brook – Irwell), Medlock (Source to Lumb Brook)
[16] Irwell (Croal – Whitewell Brook and Cowpe Brook to Rossendale STW), Ogden, Beal, Eagley Brook, Middle Brook, Bradshaw Brook
[17] Whitewell Brook, Limy Water, Irwell (Rossendale STW to Roch), Kirklees Brook, Irwell (Croal to Irk), Roch (source to Spodden and Spodden to Irwell), Tonge, Wince Brook, Medlock (source to Lumb Brook), Folly Brook and Salteye Brook
[18] City of Trees and Environment Agency (April 2017) Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments

- Publicly accessible waterfrontages – where community and business litter removal schemes are most effective;
- Where contaminated land and/or minewater discharges are known to be a problem (local knowledge required); and
- Where the waterbody also scores well on the flood risk, ecological networks and amenity ESS opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.

Limitations and Areas for further development

6.18 Certain land typologies are excluded from water quality ESS opportunity mapping because there is little feasibility of implementing cost-effective GI measures. This includes existing buildings, roads, rail, domestic gardens and cemeteries.

6.19 Lack of consistent open datasets on contaminated land and minewater discharges meant that waterbodies affected by these issues could not be included in the IMC-wide opportunity maps. However, these issues can be considered in future iterations, as and when data becomes available. These issues can in any case, be considered when drawing up an investment portfolio (see narrative on priorities above).

6.20 This study could only access EU Soils Database information. Lack of closer resolution soil data prevented scoring the soil characteristics attribute by land parcel. Such data is not currently available on an open basis for public sector bodies. Nevertheless, soil data should be purchased for projects being actively considered for water quality ESS interventions (i.e. the investment portfolio stage).

6.21 Some of the upper catchment does not have high-resolution LIDAR and thus flowpaths could not be mapped. However, these flowpaths in the upper catchment are less likely to convey polluted water and hence this limitation may not result in significant ESS opportunities being missed.

Case Study: Howard Street, Salford

Three London Plane trees were planted in a specially designed trench in Howard Street, Salford. The tree planting was carried out to gain a better understanding of the impact trees have on cleaning polluted water from road run off and managing levels of surface water. The Project is being undertaken by a Partnership between the EA, University of Manchester, City of Trees, United Utilities, Urban Vision and Salford City Council.

The University of Manchester are monitoring the quantity and quality of the rainwater as it enters and leaves the trench using specialist equipment.

The results, as of June 2016, revealed that the average water retention by the tree pit system was approximately 40%, rising to 50% during storm peaks. Storm waters were slowed by the innovative system by up to 2 hours.

For further information refer to: http://www.cityoftrees.org.uk/project/howard-street-salford

7.0 Water Resources

Value of the ESS in the Study Area

7.1 Waterbodies in the IMC supply water that is abstracted for use in a number of sectors, including for the production of energy, the provision of drinking water, and for industrial and commercial purposes. This includes both surface and groundwater that is abstracted directly from or near to waterbodies in the IMC. The local availability of water is valuable to businesses and individuals in the IMC who do not have to pay to transport water from outside the IMC.

7.2 Waterbodies within the IMC provide 180 million m^3 of water per year, which is valued at £23 million for its users in a number of sectors. The largest share in terms of both economic value and volume abstracted is for public water supply which is worth £14 million annually. Other significant uses are for the generation of energy and industrial purposes.

Table 7: Breakdown of Value of Water Resources

Water Use	Volume Abstracted in 2016 (million m^3)	Unit Resource Rent (£/ m^3)	Annual Value of Water Provisioning Service (£m)
Water supply	107	0.15	14
Production of energy	74	0.1	7
Industrial, commercial and public service	15	0.1	2
Environmental*	<1	0.3	<1
Amenity**	<1	0.15	<1
Agriculture	<1	1.25	<1
Total	**181**		**23**

**Environmental includes use in relation to river/wetland support, transfer between sources and pollution remediation*
***Amenity use includes water used for parks, golf courses, and swimming pools*

7.3 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

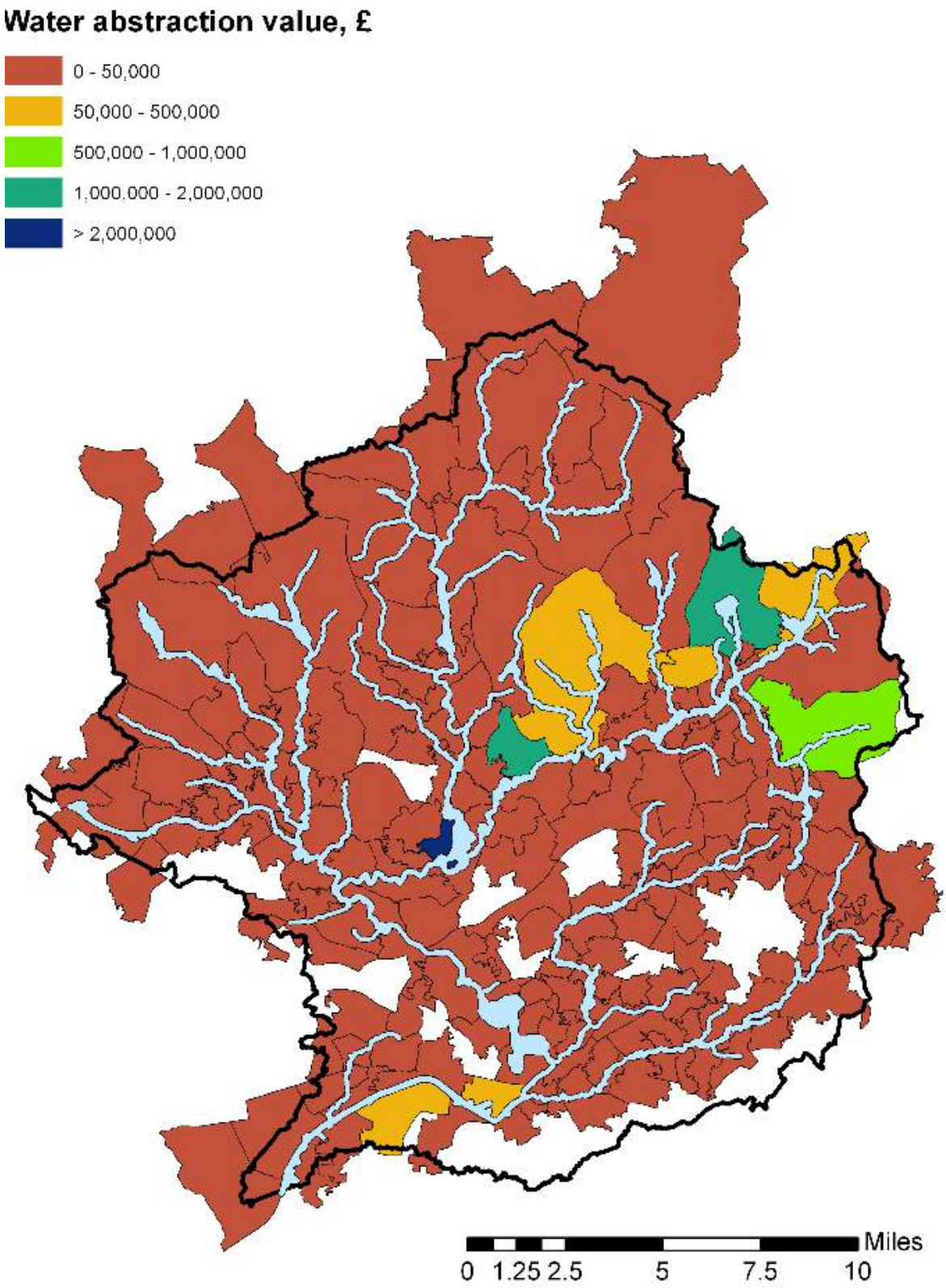


Figure 15: Value of Water Abstraction within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Issues

7.4 Provision of surface and ground water for drinking and non-drinking purposes has not, to date, been prioritised in the Natural Course project. This is because most water is sourced from abstraction points and reservoirs which are outside the scope of the project's focus on urban HMWB.

7.5 Water resources are routinely considered in more rural catchments, where seasonally-low base flows in waterbodies can negatively affect abstraction for drinking water, or the efficacy of dilution of discharges from sewage treatment works.

7.6 The Greater Manchester ESS Pinch Point Report[19] considered water resources and based on stakeholder consultation, did not consider it as a priority for intervention. Similarly, the Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments [20] did not specifically consider water resources as a topic for opportunity mapping. This may have been because other ESS policy priorities (water quality and flood mitigation) would be expected to result in enhancement to the quality and reliability of water resources.

7.7 Nevertheless, this report shows there is significant natural capital value arising from water resources in the IMC, and a theoretical scope for increase particularly in respect of energy generation.

7.8 The River Irwell Management Catchment – Evidence & Measures, Final Report February 2017[21] has waterbody output maps showing measures whose primary purpose is to address water quality issues. Some of these measures would also indirectly improve ESS related to water resources, for example micro-hydro generation schemes which could be implemented during re-naturalisation of channel features such as weirs however such schemes could conflict with biodiversity requirements.

Opportunity Assessment

7.9 ESS opportunities to enhance water resources were not specifically mapped for this study, for the reasons outlined above, and also because security restrictions prevent publication of geo-located resource maps.

7.10 Nevertheless there are general opportunities across the IMC to enhance the provision and regulation of water for drinking and non-drinking purposes. Such opportunities problems arise on land where it is feasible to implement natural environment measures which:

- Improve soil capacity to store water (re-wetting projects); and
- Create wetland habitats.

[19] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.

[20] City of Trees and Environment Agency (April 2017) Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments

[21] River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 for Greater Manchester Combined Authority

7.11 Such opportunities are mapped in respect of water quality, carbon sequestration and ecological networking opportunities, so water resource ESS opportunities are indirectly promoted.

Priority Interventions

7.12 Stakeholder interventions to improve water resources ESS will be of higher priority in the following scenarios:

- In the upper catchments where soil wetting schemes are most effective, especially above abstraction points and drinking water treatment plants managed by United Utilities (UU);
- Where the waterbody also scores well on the water quality, flood risk mitigation and Ecological Networks ESS opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners; and
- Where abstraction of water for energy generation can be achieved as part of a channel restoration process (e.g. if a weir or fish barrier can be remodelled).

Case Study: Heap Bridge Hydro-Electric Generation

At Heap Bridge in Bury, a reverse turbine hydro generator was installed during re-modelling of an existing weir on the River Roch. The project took account of ecological surveys and the electricity is used to power a nearby industrial estate.

For more information refer to: https://www.mabey.com/uk/projects/heap-bridge

8.0 Flood Risk Mitigation

Value of the ESS in the Study Area

8.1 The risk of flooding is a key factor that determines the cost and benefits of choosing to live near a waterbody. A baseline assessment of flood risk and the economic costs associated with inundation allows examination as to where the costs of flood risk are likely to be highest and where mitigation efforts could be deployed most efficiently.

8.2 Expected annual damage to residential properties from flooding is estimated to be £48 million for the study area. The location of expected damages is concentrated in a small number of locations, including areas of Bolton, Bury, Rochdale, Rossendale and Salford.

8.3 As will be shown below, some of the waterbodies where annualised costs are greatest also have above-average ESS opportunity for flood risk mitigation, notably the River Irwell (Rossendale STW to Roch) where the annualised cost is £6.6m.

Table 8: Breakdown of Flood Damages in Study Area

Variable	Value
Annualised average damage cost	£4,900
Annualised expected flood damages for residential properties located in flood risk areas	£48 m

8.4 The annualised damages shown in Table 8 are calculated by using models that predict the number of residential properties exposed to flood risk under different flood return periods and weighting annual average damages by the probability of being flooded in any given year.

8.5 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

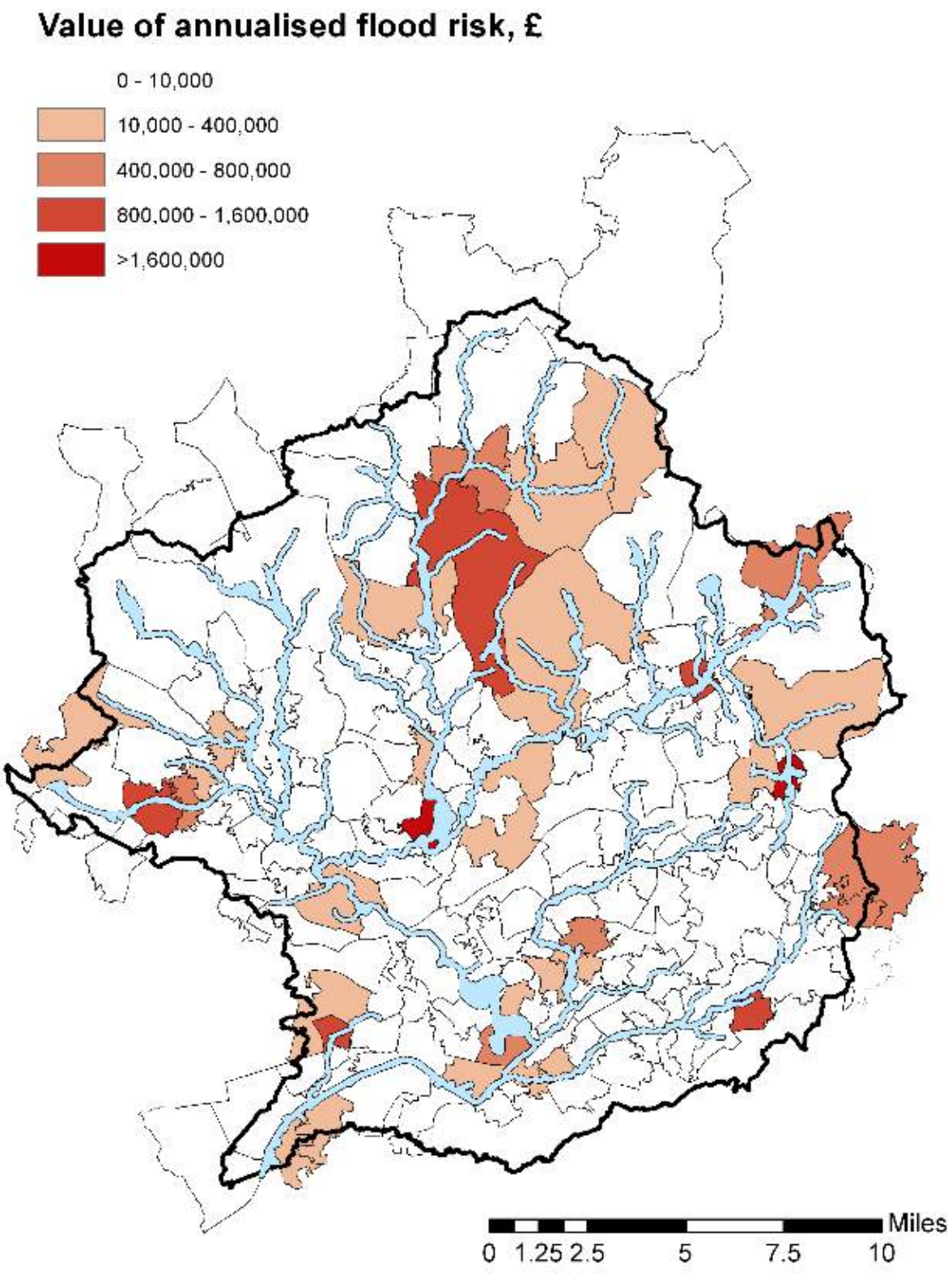


Figure 16: Value of Annualised Flood Risk in IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Issues

8.6 Given the potential disastrous environmental, social and economic effects of flooding, mitigation of flood risk is a key issue for the GMCA and the Irwell Catchment Partnership. The effects of flooding events include loss of commercial and industrial revenues, increased insurance costs and the time taken for vulnerable communities to recover from flooding.

8.7 No single approach or measure can mitigate all flood risk, but the Irwell Strategic Natural Flood Risk Management Study (JBA, 2017) provides research into the IMC. The Study uses detailed models to assess the potential for use of natural flood risk management techniques alongside more traditional engineering solutions. This study uses data from the JBA research to inform the flood mitigation opportunity mapping.

Opportunity Assessment

8.8 ESS opportunities to reduce flood risk arise on land where it is feasible to implement natural environment measures which:

- Are in catchments of area less than 10km^2 [22];
- Result in re-wetting (and water storage) of land in flowpaths or run-off attenuation features (RAF's); or
- Roughen the landscape thereby slowing the flow of surface water towards the WFD waterbodies.

8.9 Need for flood risk management is defined by the presence of properties (commercial and residential) at risk of flooding. In this case, the areas of need are distant from the areas of potential intervention. The opportunity mapping focuses on the identification of potential opportunities for the incorporation of flood risk management schemes and projects.. The prioritisation stage (described later) draws together the link between the opportunity areas and the areas of greatest need.

8.10 ESS opportunities for flood risk mitigation are scored in terms of the attributes listed at Table 9.

Table 9: Ecosystem Service Opportunity Assessment for Flood Risk Mitigation

Attribute	Score	Rationale
Size of upstream catchment	Catchments less than 5km^2 score 2, catchments between 5 and 10km^2 score 1	Larger catchments are less likely to respond to naturalistic flood management measures; in that these measures do not significantly affect peak flows in waterbodies with larger catchments

[22] Environment Agency (2010) "Working with natural processes to manage the risk of flood and coastal erosion risk". Guidance document.

Attribute	Score	Rationale
Runoff Attenuation Features (RAF) and surface water flowpaths	Parcels that contain both RAF and active surface water flow paths score 1.	RAF opportunities include natural depressions and small channels between 100-500m2 which can be created through waterbody improvements and bunds. RAF can reduce peak runoff. RAF, in combination with surface water flow paths, are most effective.
Enhanced Urban Opportunities (from JBA “Working With Natural Processes Opportunity Mapping”.)	Parcels which intersect with urban areas receive a score of 1.	Greenspaces provide increased permeability and offer potential reduced surface run off levels when in urban environments. JBA identify areas potentially suitable for tree planting, reed beds or SUDS
Rural Losses (from JBA study)	Parcels which are designated as Greenspace or semi natural grassland score 1, and agricultural land score 2.	Through modifications to the land use and landscape management techniques, damaged soil structure can be improved to increase soil moisture capacity.
Roughening Up the Landscape (from JBA study)	Parcels that contain land suitable for scrub planting score 1.	Scrubland creation has less impact on the volume of the runoff peak, but can significantly delay the timing of the peak runoff in headwater catchments. Further downstream it can both delay and reduce runoff peak
Land potentially useful for re-wetting or wetland creation	Areas that are potentially suitable for re-wetting score 1	Where land can hold more water, opportunities arise to create or restore wetland habitats to reduce flood risk

8.11 ESS opportunities in respect of flood risk mitigation are mapped by land parcel. A flood risk mitigation ESS opportunity heat-map is generated (see Figure 17).

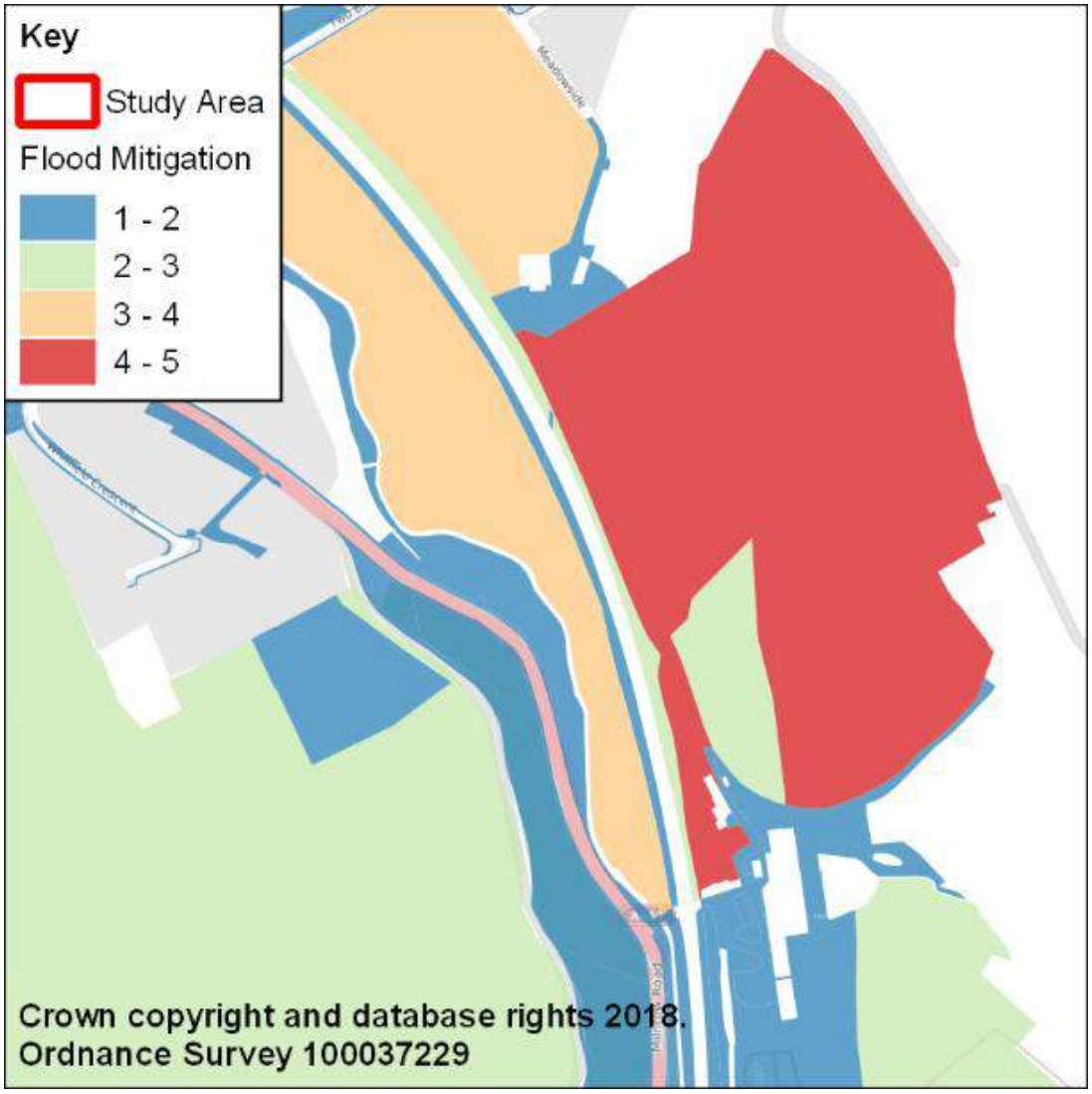


Figure 17: Flood Mitigation ESS Opportunity Heat Map

Priority Interventions

8.12 Stakeholder interventions to improve ESS in respect of flood risk mitigation will be of higher priority in the following scenarios:

- In the waterbodies where annualised risk costs are highest and where ESS opportunities are above average. These can be identified by comparing information in Appendices H and I. In particular:
    - Irwell (Rossendale STW – Roch): £6.1m annual risk cost;
    - Roch (Source to Spodden): £2.9m annual risk cost;
    - Middle Brook: £2.7m annual risk cost;
    - Ogden: £2m annual risk cost; and
    - Whitewell Brook: £1.1m annual risk cost.

  The above recommendations are subject to flood risk modelling showing that an appreciable reduction in risk would be experienced by vulnerable downstream communities and property owners (as noted above, such modelling is outside the scope of this study);

- Opportunity areas highlighted in the Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments[23] e.g. certain industrial, commercial and residential properties where local interventions such as swales, SUDS, tree-planting may (if verified through modelling) reduce the frequency of flooding; and
- Where the waterbody also scores well on the water quality, ecological networks and carbon sequestration ESS opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.

Limitations and Areas for Further Development

8.13 This study builds on the earlier work by JBA (2017), City of Trees (2017) to confirm that there are numerous opportunities to implement natural flood risk management measures throughout the IMC. However, there is still a need for detailed modelling to confidently predict the extent of mitigation that would be experienced by downstream properties at risk.

8.14 Some of the upper catchment does not have high-resolution LIDAR and thus flowpaths could not be mapped. However, these flowpaths in the upper catchment are less likely to convey significant volumes of water at times of peak hydrograph and hence this limitation may not result in significant ESS opportunities being missed.

Case Study: Urban Wetland and Flood Defence Scheme in Salford

An urban wetland and flood defence scheme in Salford was completed in early 2018. The £10 million project covers 69 acres adjacent to the River Irwell and will protect 2,000 properties from flooding by holding up to 650 million litres of water during a flood event[1]. A wetland reserve and public footpath network has been created alongside the flood defences to optimise the benefits of the scheme to include habitat creation and leisure and recreation opportunities. This example demonstrates uplift in natural capital.

For more information refer to:
https://www.gov.uk/government/news/environment-agency-completes-10-million-flood-storage-basin-on-world-wetlands-day

[23] City of Trees and Environment Agency (April 2017) Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments

9.0 Carbon Sequestration

Value of the ESS in the Study Area

9.1 Vegetation plays an important role globally in capturing and storing carbon dioxide. The study area contains wooded areas that are particularly important for the sequestration of carbon dioxide. The annual value of sequestration for woodland in the study area amounts to around £1 million per year (see breakdown in Table 10).

Table 10: Breakdown of the Value of Carbon Sequestration within the Study Area

Variable	Value
Annual sequestration	21,000 tCO_2
Annual value of woodland sequestration	£1 million

9.2 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

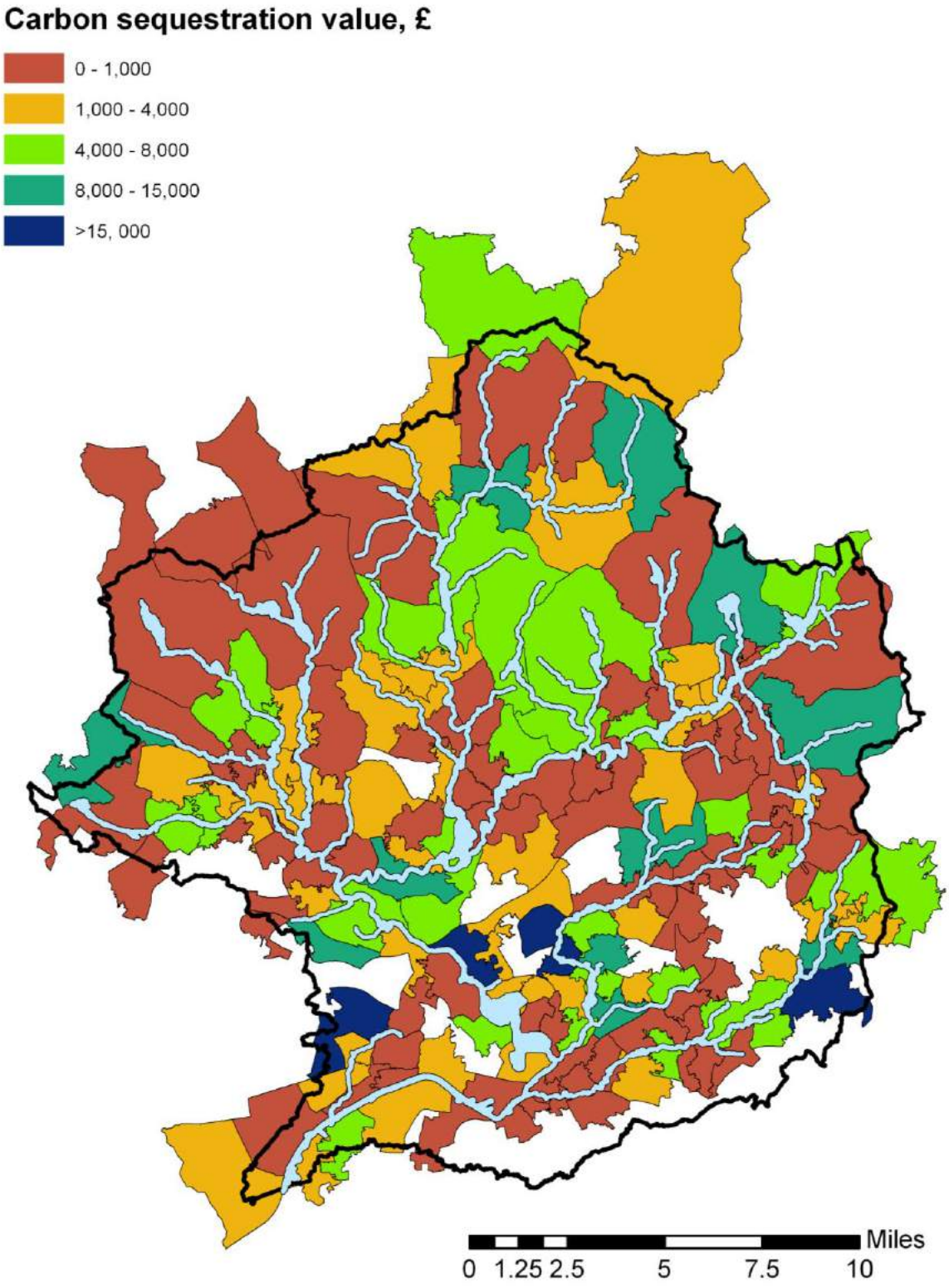


Figure 18: Carbon Sequestration Value within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Issues

9.3 The Greater Manchester Climate Change Strategy and associated implementation plan[24] focuses on significant reductions in the city-region's carbon footprint through attention to industrial processes and decarbonisation of energy and transport systems. There are parallel actions to improve air quality and flood resilience. One of the five strands of the strategy relates to "natural capital" with an objective to ensure it is embedded in policy and decision-making by 2020, leading to tree-planting, "no net loss" approaches to development and environmental resilience projects such as tree planting and water quality improvements, being fully in place by 2020 with achievable goals by 2035.

9.4 Lancashire's climate change strategy[25] also has a significant commitment to natural capital enhancement for the purposes of carbon sequestration, with estimates of kilotonnes of carbon dioxide that could be sequestered through tree-planting and moorland re-wetting initiatives.

9.5 There is now a well-established body of research and good practice in urban-fringe and upland carbon sequestration measures, with UU and Royal Society for the Protection of Bird's (RSPB) Sustainable Catchment Management (SCaMP) plans being a nationally-recognised example of this. Under the Government's 25 Year Environment Plan, future financial support for landowners will depend on good soil husbandry and will promote measures to improve carbon sequestration.

9.6 The existing natural capital value of the IMC in respect of carbon sequestration will help advocate future investment in projects which add to this baseline.

Opportunity Assessment

9.7 ESS opportunities in respect of carbon arise on land where it is feasible to implement natural environment measures which:

- Increase the capacity of soil to store carbon, typically by reducing cultivation and drainage which leads to oxidisation of soil carbon;
- Increase woodland cover, notably of faster-growing species; or
- Increase wetland habitats (reedbeds, bogs, pools and lakes).

9.8 ESS opportunities for carbon sequestration are scored in terms of the attributes listed at Table 11.

[24] Greater Manchester Low Carbon Hub (2016) Climate Change and Low Emissions Strategies: Whole Place Implementation Plan 2016 to 2020.
[25] Lancashire Climate Change Partnership (2009) Lancashire Climate Change Strategy 2009-2020

Table 11: Ecosystem Service Opportunity Assessment for Carbon Sequestration

Attribute	Score	Rationale
Soil Sequestration Capacity	Parcels with Gley Soil score 2, Loam Soil 1, and Sandy Soil 0 Unfortunately, the EU soils database (the only open data available within budget) is not sufficiently fine-grained in this urban context to enable this scoring to take place accurately.	Some soils have a higher natural capacity to sequester carbon than others. While any soil can sequester carbon, clay or peat based soils have the greatest capacity to lock up organic material, while lighter sandy or loamy soils have lower capacity for increased sequestration
Potential for Agricultural Land Use Change	Agricultural Land parcels score 2, Permanent Grassland 1 and Woodland 0	Step-change increases in carbon sequestration can be achieved by moving land from arable to woodland
Potential for Urban and Amenity Land Use Change	Urban land parcels score 2, Greenspace 1 and Woodland 0	Step-change increases in carbon sequestration can be achieved by moving land to woodland
Land Potentially Used for Re-Wetting/ Wetland	Land parcels suitable for re-wetting score 1	Areas of land adjacent of water courses with currently limited or low flow paths, to highlight land with the potential for wetland creation

9.9 ESS opportunities in respect of carbon sequestration are mapped by land parcel.

9.10 A carbon sequestration ESS opportunity heat-map is generated (see Figure 19).

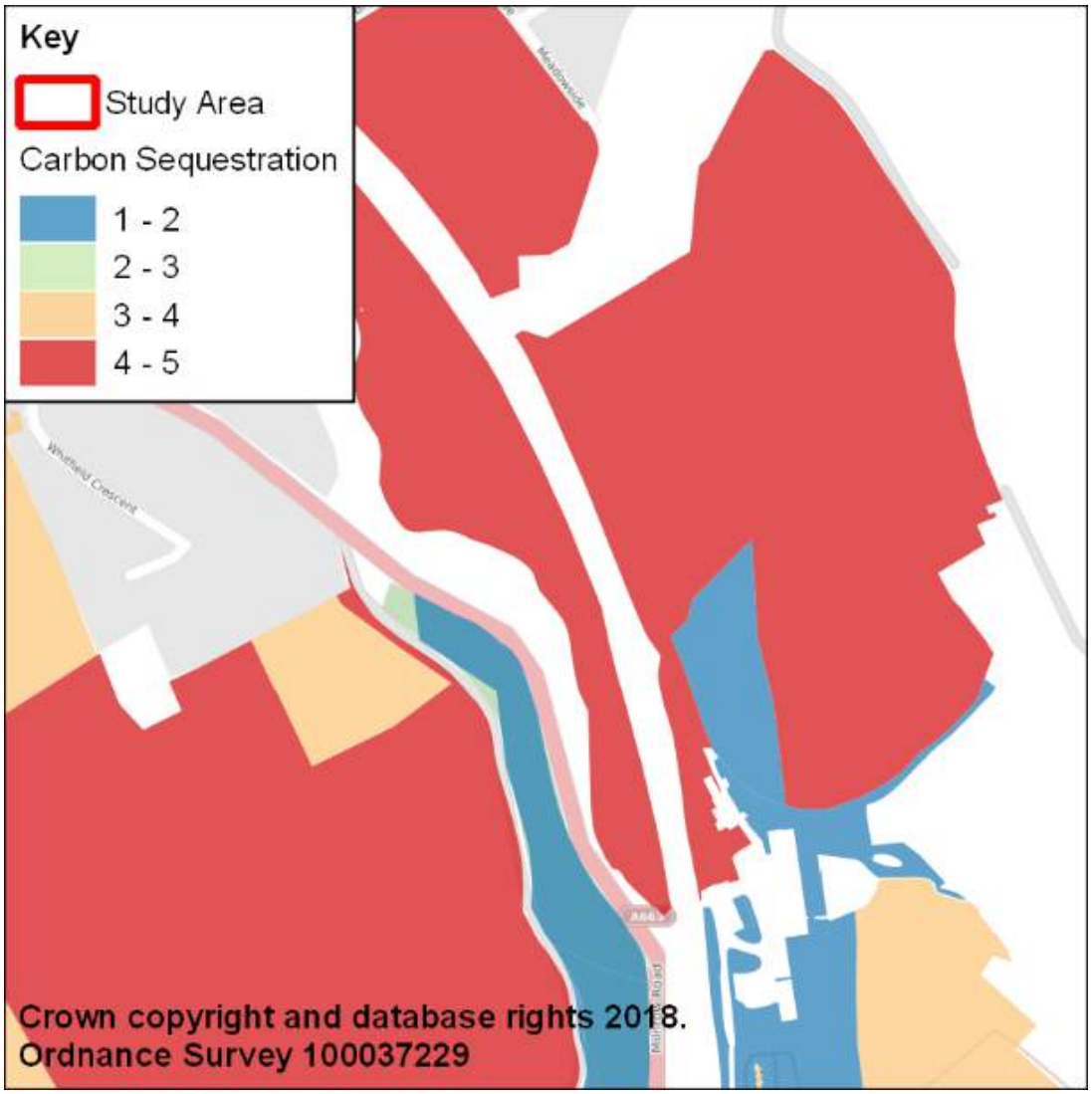


Figure 19: Carbon Sequestration ESS Opportunity Heat Map

Priority Interventions

9.11 Stakeholder interventions to improve ESS in respect of carbon sequestration will be of higher priority in the following scenarios:

- In waterbodies which score above-average for carbon sequestration[26] ESS opportunity (see Appendix H).
- Where the waterbody also scores well on the water quality, flood risk mitigation, amenity and ecological networks opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.
- In areas with relatively large landholdings, typically agricultural and estate landscapes in the upper catchment. Here it is most likely that a landowner can develop a bespoke integrated countryside stewardship scheme to focus on soil

[26] Beal, Bradshaw Brook, Croal (inc Blackshaw Brook), Irwell (Cowpe Brook to Rossendale STW), (Rossendale STW – Roch), (source to Whitewell Brook), Limy Water, Medlock (Lumb Brook to Irwell), Ogden, Roch (Source to Spodden), Roch (Spodden to Irwell)

health, tree-planting and wetland protection and secure support from Natural England (NE), Forestry Commission and possibly carbon offset providers.

Limitations and Areas for Further Development

9.12 This study could only access EU Soils Database information. More fine-grained soil data would enable scoring soil characteristics by land parcel.

9.13 Opportunity can be explored to link businesses that aspire to become carbon neutral with carbon sequestration projects in the IMC. This could be achieved through carbon-offset payments and/or volunteering in tree-planting and upland management.

Case Study: Northern Forest

Woodland Trust and The Community Forest Trust plan to create a Northern Forest which will create a woodland band across the country from Liverpool to Hull (following the M62). The Forest will comprise 50 million trees and will take 25 years to create. It is estimated that the Forest will store over 7 million tonnes of carbon. Other benefits will include reducing flood risk, improving air quality and improving health and wellbeing.

For more information refer to:
https://www.woodlandtrust.org.uk/blog/2018/01/new-northern-forest/

10.0 Leisure and Recreation (including Health)

Value of the ESS in the Study Area

Leisure and Recreation

10.1 Recreational visits to green spaces in the study area are valued at £190 million annually. This is based on an estimated 55 million visits to these spaces annually, highlighting the large demand and range of outdoor activities and reasons people have for enjoying these spaces. For an average resident located in the study area, they enjoy £127 worth of benefits per year.

10.2 Recreational spaces are valued highest where they are located near to population centres, as can be seen in Figure 20. Hotspots for leisure and recreation are located in Manchester and Salford, and also in parts of Bury and Rochdale. This highlights the particularly valuable role that natural capital has in highly urbanised areas.

Table 12: Breakdown of the Value of Leisure and Recreation within the Study Area

Variable	Value
Number of estimated visits to recreation sites per year	55 million
Total value of leisure and recreation	£190 million
Per person value	£127

10.3 The number of visits and value placed on these spaces in Table 12 are based on what might be expected for a typical greenspace with given features in the study area, accounting for the availability of other greenspace and characteristics of the local population. Recreational values reported here will not take account of aspects such as uniqueness of sites and particular types of recreational activities.

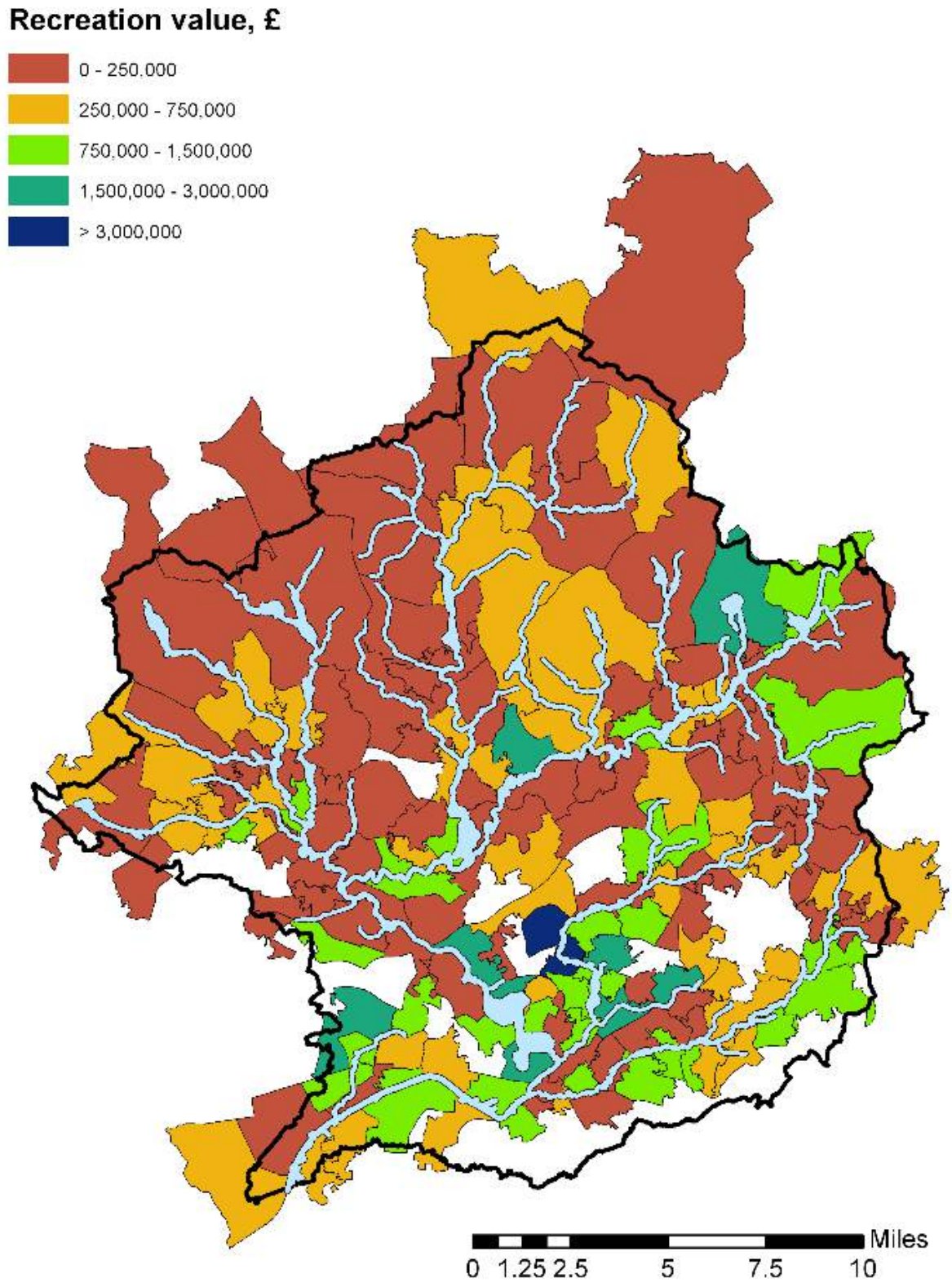


Figure 20: Leisure and Recreation Value within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Physical Health

10.4 The availability of publicly accessible green spaces reduces the cost of physical disease by £98 million per year. This reflects the avoided costs for individuals, the public sector and businesses due to the physical activity conducted in these spaces. Higher levels of physical activity for the average individual have been shown to reduce the risk of certain diseases, such as heart disease, diabetes, and a number of cancers, leading to higher life expectancy. For a typical individual living in the study area, this avoided cost equates to £66 per person annually.

10.5 Due to the estimated number of visits to green spaces being higher in more urban areas, avoided costs due to physical activity are heavily concentrated around waterbodies in Manchester, Bury, and Rochdale.

Table 13: Breakdown of the Cost Savings for Physical Health within the Study Area

Variable	Unit
Estimated number of active visits	27 million
Total avoided costs due to improved physical activity in the IMC	£98 million
Per person cost saving (persons of all ages)	£66

10.6 Active visits in each MSOA are calculated using the assumption from White et al. (2016) that 50% of visits to green spaces are active. For each administrative area in the study area, the number of active (5 x 30 minutes exercise per week) visits to green spaces are estimated using the ORVal tool. The monetary value of each active visit is then calculated by the number of Quality Adjusted Life Years (QALYs) associated with each visit.

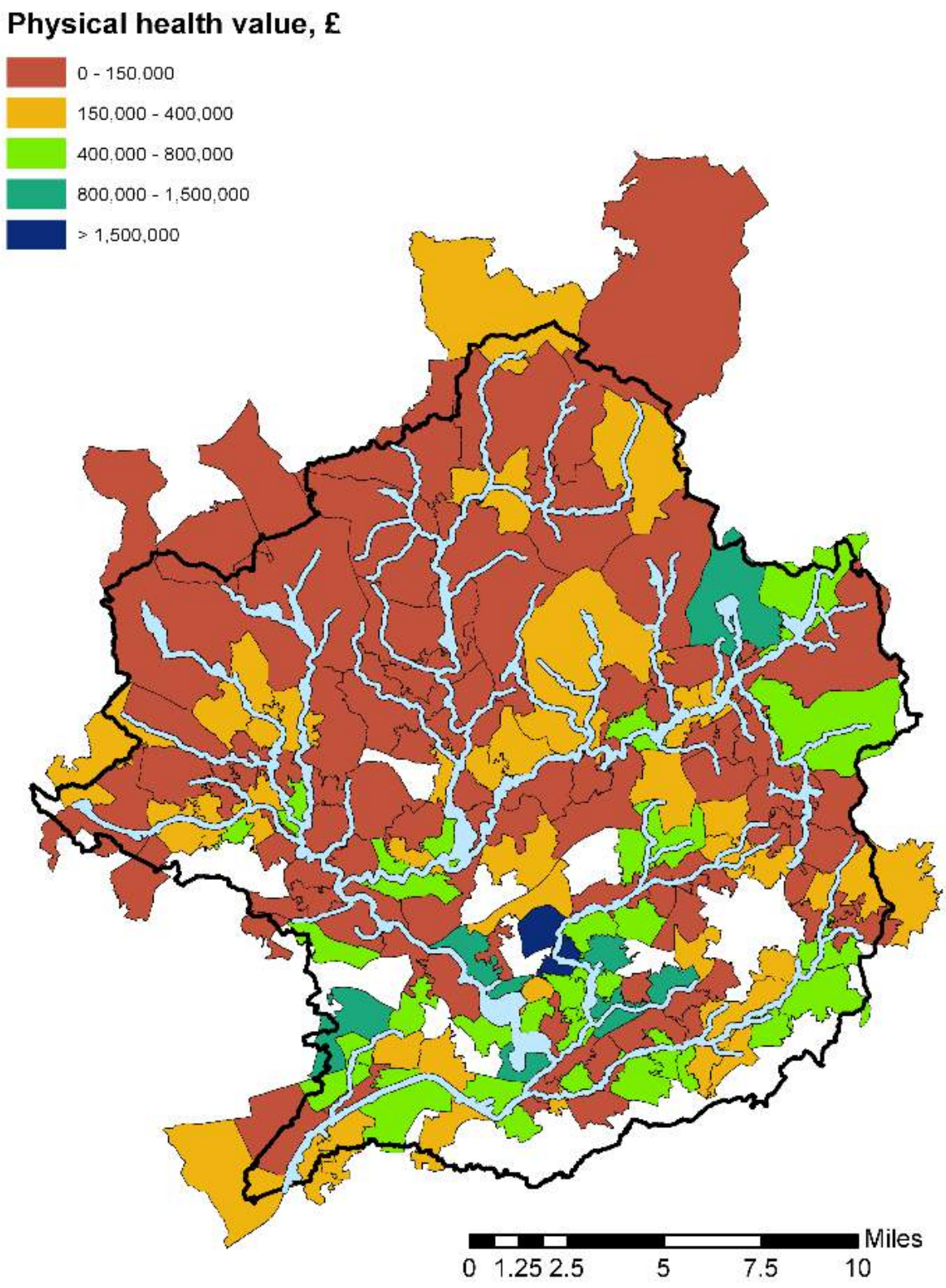


Figure 21: Value of Physical Health within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Mental Health

10.7 The avoided costs of mental illness also represent a substantial source of value from natural capital, with cost savings estimated to be close to £60 million on an annual basis. This value reflects evidence of the link between the availability of green space and perceived mental health. These costs savings accrue not only to individuals, but also to public services and businesses who benefit from a healthier and more productive population. Although the average person avoids costs of £39 a year due to the availability of green spaces, Figure 22 illustrates that these benefits are most significant in urban areas of the IMC. This underscores the fact that although there are urban areas that greatly benefit from availability of green spaces, increasing the accessibility of green spaces in urban areas currently deprived would yield the most significant social returns.

Table 14: Breakdown of the Cost Savings for Mental Health within the Study Area

Variable	Unit
Total avoided costs due to improved mental health in IMC	£59 million
Cost savings from green space as a proportion of total mental health	1%
Per person cost saving (persons of all ages)	£39*

**Per person avoided costs of mental illness are taken from Centre of Mental Health (2010).*

10.8 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

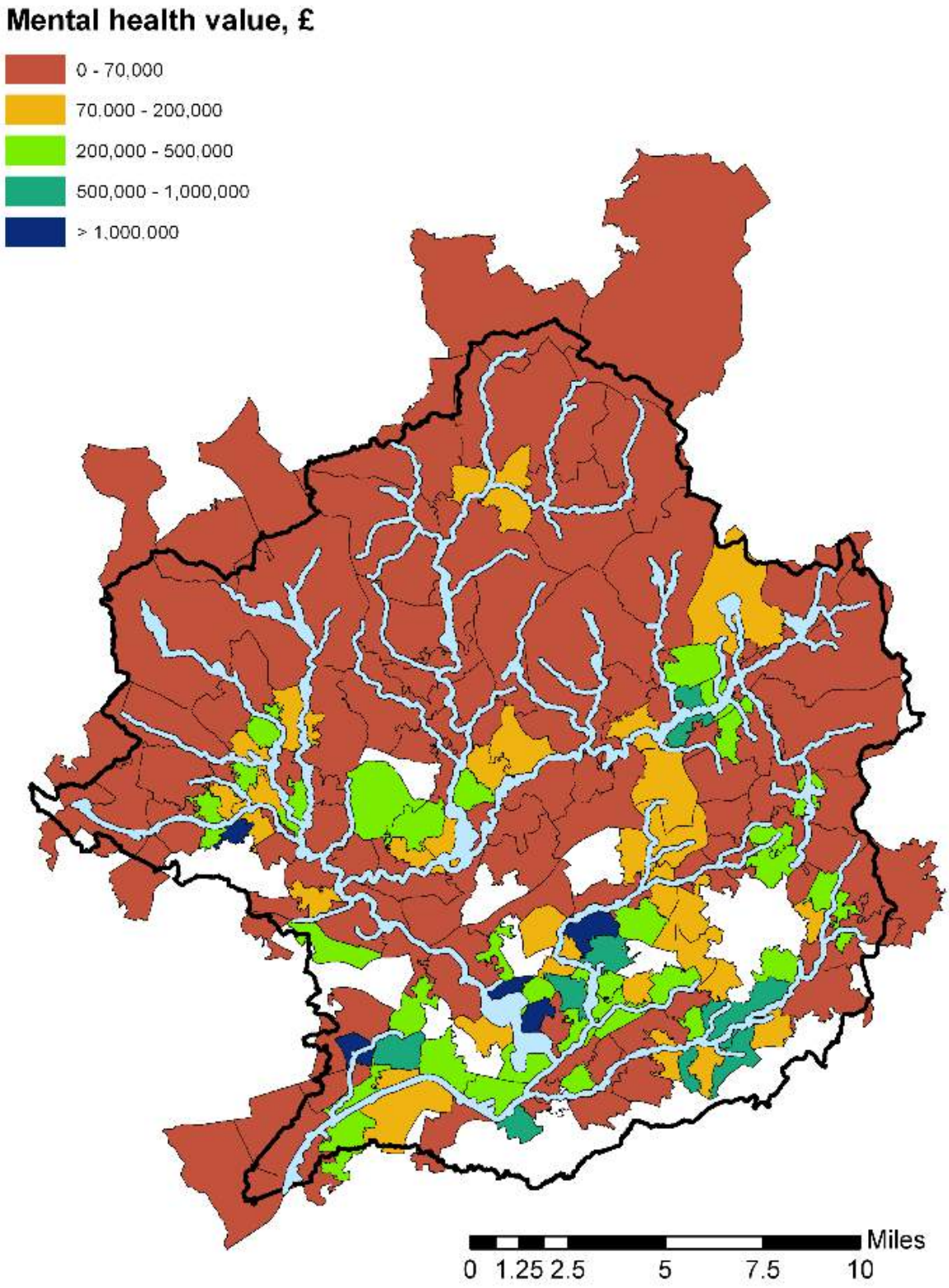


Figure 22: Value of Mental Health within IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Issues

10.9 The Greater Manchester ESS Pinch Point Report[27] includes public recreation and venue for green travel routes as one of Greater Manchester's eight priority ESS with the following 'pinches' (issues which need to be addressed to maximise ESS) identified:

- The need to maximise and increase the cross linkages and flexibility of our already extensive existing network of green recreational/active travel routes, including waterbody corridors, canals and National Cycle Network; and
- The need for new mechanisms for resourcing green space provision and its management, increasing the range of stakeholders contributing to it, to ensure continued/increasing use of GM's public greenspaces for recreation and active travel.

10.10 The Report summarises the strategic activities/actions which would be needed to maximise ESS benefits. For public recreation and venue for green travel routes, this includes:

- Public Greenspaces: Better-managed, more multifunctional formal and informal public greenspaces;
- Rivers and canals: A more natural river network, with fewer culverted sections and greater capacity to store floodwaters. Canals that act as corridors for people and wildlife, that provide climate change adaptation, and support economic activity; and
- River valleys: An integrated approach to managing the public greenspaces and private land in Greater Manchester's river valley network, with better linkages through them for people and wildlife.

10.11 The Report states that there is a strongly positive interaction between public recreation and venue for green travel routes and the other priority ESS of water quality management and visual/ aesthetic.

10.12 The Accessible Natural Greenspace Standard (ANGSt) produced by NE recommends that everyone, wherever they live, should have accessible natural greenspace:

- Of at least 2 hectares in size, no more than 300 metres (5 minutes' walk) from home;
- At least one accessible 20 hectare site within two kilometres of home;
- One accessible 100 hectare site within five kilometres of home; and
- One accessible 500 hectare site within ten kilometres of home; and
- A minimum of one hectare of statutory Local Nature Reserves per thousand population.

10.13 Although superseded, PPG17's Companion Guide for carrying out open space assessments has not yet been replaced and can still be considered as best practice.

[27] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.

10.14 Proximity and access to good quality greenspaces is a core aim of national and local government policy. The Greater Manchester Strategic Framework[28] 2016 details the variety of outdoor recreation opportunities, promoting the benefits of leisure and recreation including quality of life, good health and increasing attractiveness of the region. The GMSF states this will be achieved through 5 activities, one of which is focussed on significantly increased access to the waterbody corridors.

10.15 The primary driver for establishing a vision for health across Greater Manchester is provided by the Greater Manchester Health and Wellbeing Strategy[29]. The strategy has a holistic approach to health including prevention of illness, access to appropriate treatment, integration of services and sustainability in service provision. Core to the strategy is the shifting of focus from care provision to prevention, through active promotion of healthy lifestyles. Similarly in Lancashire, the Health and Wellbeing Strategy[30] recognises the value of using countryside and greenspaces for healthy lifestyles alongside a broader leisure and recreation use.

Opportunity Assessment

10.16 ESS opportunities to address leisure and recreation deficiency and thus enhance health, can be identified where it is feasible to:

- Review and improve existing facilities for healthy activities including passive and active recreational facilities; and
- Improve or implement connectivity to nearby spaces through footpath and cycle route investment.

10.17 ESS opportunities arise where there is a need for greater access to spaces and facilities. Need in this case is defined by:

- Populated areas, with need increasing in proportion to levels of health deprivation;
- Greenspaces close to schools; and
- Waterbody corridor greenspaces close to strategic development sites which will enable existing and incoming residents and workers to participate in outdoor activities.

10.18 ESS opportunities for leisure and recreation are scored in terms of the attributes listed at Table 15.

[28] http://gmsf-consult.objective.co.uk/portal/2016consultation/gmsfoct16?pointId=s1476450796180#section-s1476450796180

[29] GMCA (2016) Greater Manchester Health and Wellbeing Strategy

[30] Lancashire County Council and NHS (undated) Lancashire Health and Wellbeing Strategy

Table 15: Ecosystem Service Opportunity Assessment for Leisure and Recreation

Attribute	Score	Rationale
Proximity to People	Scores awarded on a 1-3 scale. Land parcels in areas of high deprivation in close proximity to greenspaces achieve the highest scores	Where residential properties are located close to land that provides formal and informal leisure and recreation opportunities, the greater the opportunities for local residents to be engaged in leisure and recreation and derive the associated health benefits
Proximity to Strategic Development Sites	Land Parcels with >20ha accessible greenspace within 2km of Strategic Development Sites score 1	Areas of Greenspace, Woodland, and Semi Natural Grassland near GMSF strategic development sites (Commercial, Industrial and Housing 2016) will have greater opportunities for local residents, workers and visitors to be engaged in leisure and recreation and derive the associated health benefits. Greenspaces, Woodlands, and Semi Natural Grassland are spatially clustered. Clusters >20 hectares within 2km of Housing, Office or Industrial Allocation Sites are scored.
Proximity to Schools	Land Parcels within 2km of a School score 1	Areas of greenspace close to schools have greater opportunities for school children and families to be engaged in leisure and recreation. Access to high quality open spaces is critically important to promoting children's physical health and wellbeing

10.19 ESS leisure and recreation opportunities are mapped by Land Parcel. A leisure and recreation ESS opportunity heat-map is generated (see Figure 23).

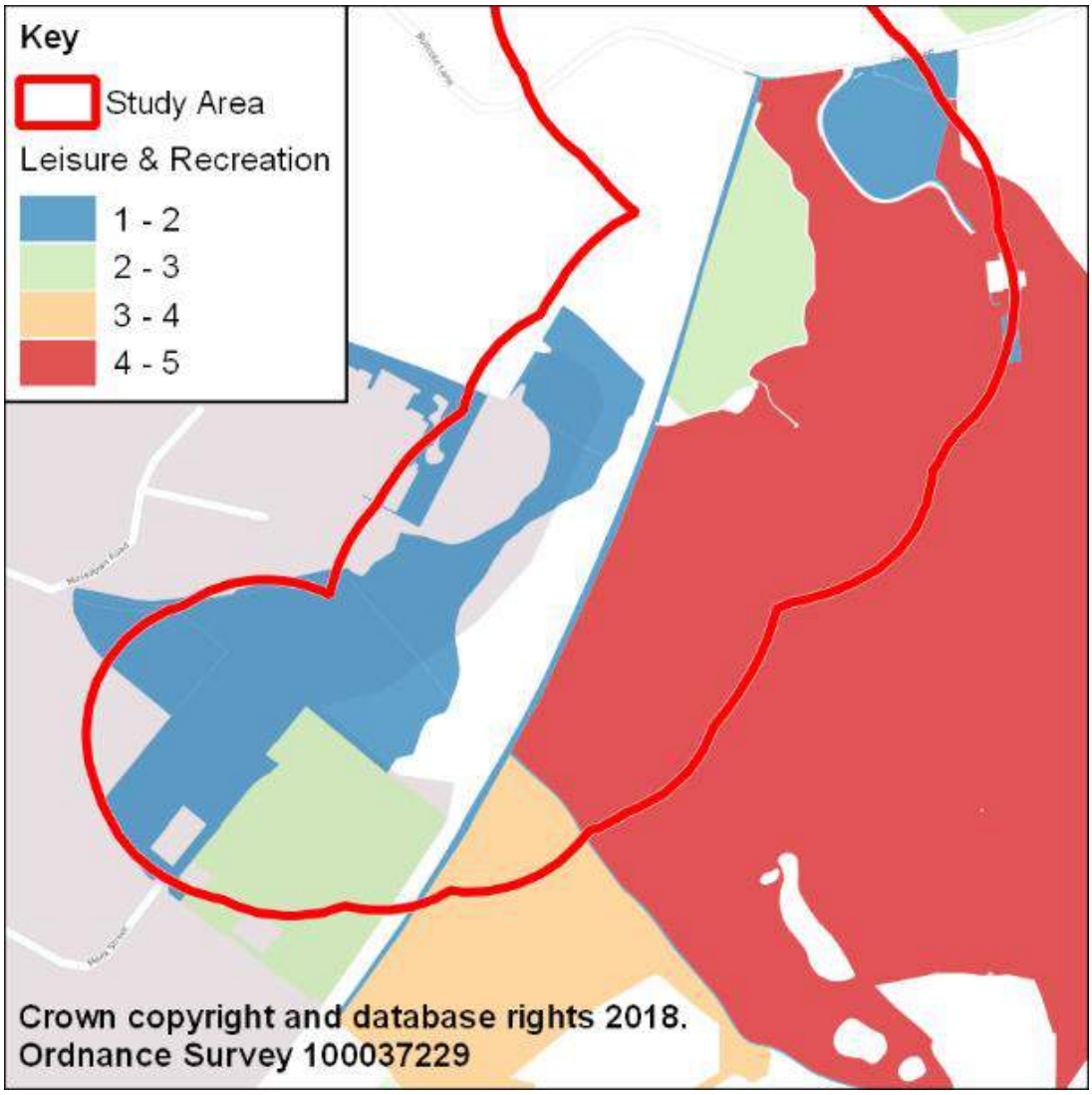


Figure 23: Leisure and Recreation ESS Opportunity Heat Map

Priority Interventions

10.20 Stakeholder interventions to improve ESS in respect of leisure and recreation and Health will be of higher priority in the following scenarios:

- In the highly-populated waterbodies where natural capital values per head for leisure, recreation and health are higher than average and there is a need to provide and maintain waterfront GI to benefit health. This applies to:
    - Folly Brook and Salteye Brook (62,000 people)
    - Irk (Wince to Irwell) (120,000 people)
    - Irwell (Croal to Irk) (120,000 people)
    - Irwell / Ship Canal (Irk to confluence with Mersey) (250,000 people)
    - Medlock (Source to Lumb Brook) (120,000 people)
    - Medlock (Lumb Brook to Irwell) (100,000 people)
    - Middle Brook (79,000 people)
    - Roch (Spodden to Irwell) (93,000 people)

- In other less-populated waterbodies where the leisure and recreation ESS opportunity score for land parcels is above average as shown in Appendix H. This applies to:
    - Astley Brook (30,000 people)
    - Irwell (Cowpe Brook to Rossendale STW) (8,200 people)
    - Irwell (Source to Whitewell Brook) (9,500 people)
    - Naden Brook (6,500 people)
    - Spodden (25,000 people)
- Where the land parcel also scores well on the amenity and air quality ESS opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners;
- Where Local Plans and GMSF have strategic development allocations within 500m of the existing greenspace; and
- Where Local Planning Authorities have identified deficiencies in quality, quantity and accessibility of open spaces, especially semi-natural greenspaces.

Limitations and Areas for Further Development

10.21 Certain land typologies are excluded from leisure and recreation ESS opportunity mapping because there is little feasibility of implementing cost-effective interventions and measures. This includes buildings, roads, rail, agricultural land and greenspace parcels less than 0.2ha in area.

10.22 The strategic development sites used in the methodology are the draft GMSF 2016 Residential, Industrial and Office allocations.

Case Study: River Medlock Restoration Scheme

In 2014, a 300m stretch of the River Medlock in Clayton Vale has been partially restored. The works were driven by the WFD and was carried out through a partnership between Irwell Rivers Trust, Manchester City Council, the EA, Groundwork and Friends of Clayton Vale. Thousands of Accrington bricks were removed to restore a more natural river flow and a weir was removed which enabled fish migration again. As a result of these works the stretch of river has become a well-used community and environmental asset. The works costs along the 300m cost approximately £400,000[1].

For further information refer to:
http://www.manchester.gov.uk/download/downloads/id/25562/river_medlock_restoration.pdf.

11.0 Amenity

Value of the ESS in the Study Area

11.1 The amenity value of green spaces in the IMC is estimated to be worth £79 million. This is calculated according to preferences that people have for living in locations with different amenities and the prices they are willing to pay to for property in these locations. Typically, people will pay to live in locations that provide easier access to green space, better quality environments and aesthetic appeal. In the IMC, this translates into the average household paying a premium of £125 per year to live within 300m of a publicly accessible green area. Figure 24 illustrates that amenity values are particularly high in areas surrounding Manchester, where property prices are high. Areas in the north of the IMC do not see a significant share of their property value spent on this type of amenity owing to the large amount of natural habitat already present in these areas.

Table 16: Breakdown of the Value of Amenity within the Study Area

Variable	Unit
Total amenity value revealed through residential property prices	£79 million
Value of amenity services proportional to total residential property value	2%
Average annual value per person	£125

11.2 The amenity value shown in Table 16 is estimated by calculating the number of residential properties that fall within 300m of a publicly accessible greenspace in MSOAs in the study area. A 5% uplift of the average value for these properties is assumed based on a review of the literature by Konijinendjk et al. (2013).

11.3 Refer to Appendix G for the Natural Capital Accounts by Waterbody and District.

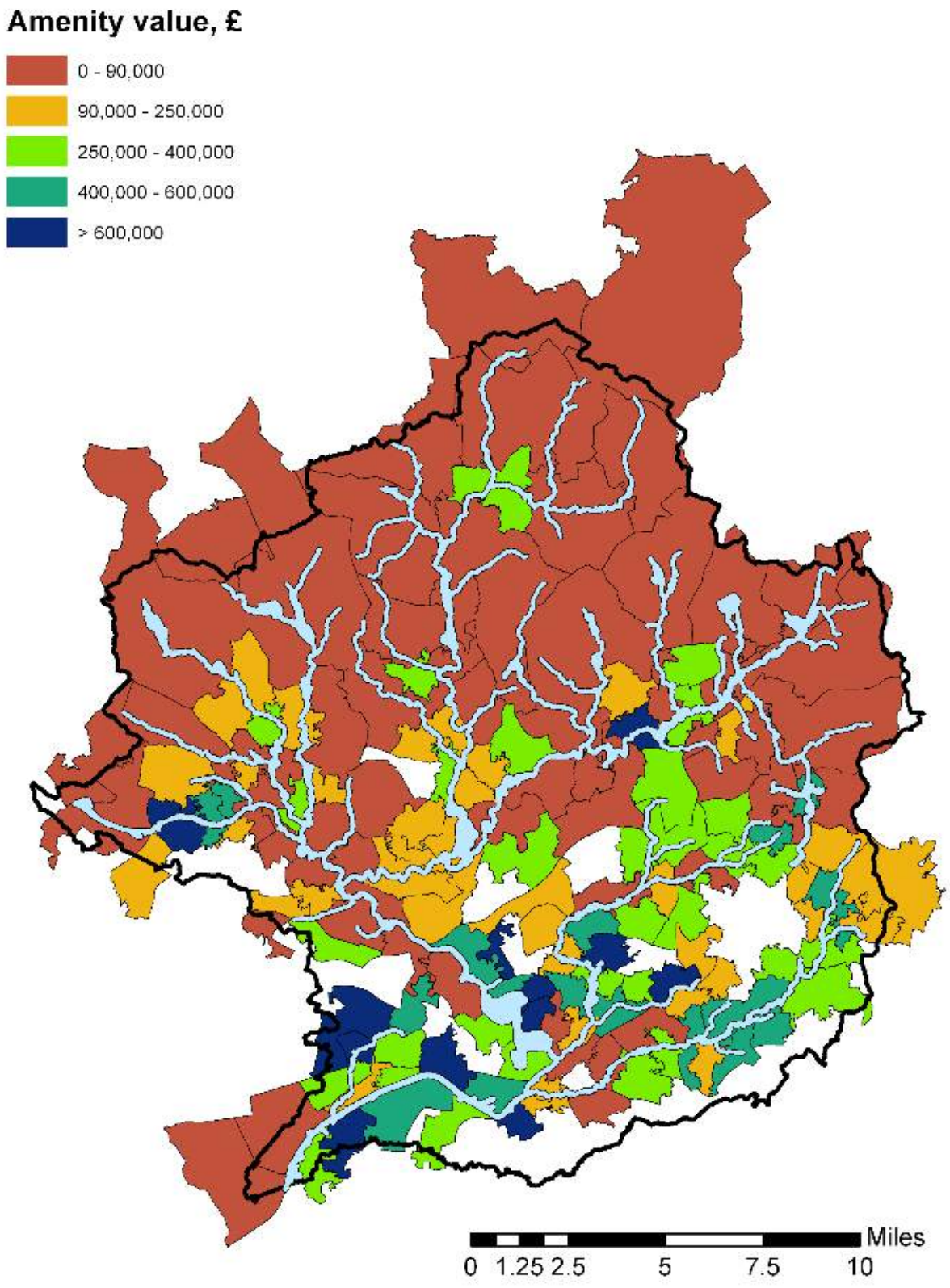


Figure 24: Value of Amenity within the IMC (values are reported for all MSOAs that overlap with the 100m buffer around each river corridor)

Issues

11.4 The Greater Manchester ESS Pinch Point Report[31] highlights the importance of amenity and visual and aesthetic impacts of GI.

11.5 Visual and aesthetic impacts are one of Greater Manchester's eight priority ESS with the following 'pinches' (issues which need to be addressed to maximised ESS) identified:

- The need to maximise the role GI retrofitting, especially into areas of deprivation, plays in improving aesthetics and quality of place; and
- In doing this, increasing the levels of GI provision, particularly street and forest scale trees and open spaces, within our regeneration and economic growth priority areas.

11.6 The Greater Manchester ESS Pinch Point Report[32] summarises the high level strategic activities/ actions which would be needed to maximise ESS benefits. For aesthetics, this includes:

- Public Greenspaces: Better-managed, more multifunctional formal and informal public greenspaces;
- Rivers and canals: A more natural river network, with fewer culverted sections and greater capacity to store floodwaters. Canals that act as corridors for people and wildlife;
- River valleys: An integrated approach to managing the public greenspaces and private land in Greater Manchester's river valley network, with better linkages through them for people and wildlife;
- Trees and woodlands: More and better-managed woodlands and more trees in town centres, along transport corridors and in neighbourhoods where they are lacking;
- Urban GI retrofitting: More street trees, soft landscaping, green roofs and walls and sustainable drainage built into the fabric of our urban areas; and
- Private gardens: Gardens with a greater proportion of permeable surfaces and more wildlife-friendly gardening practices.

11.7 The Report states that there is a strongly positive interaction between visual/ aesthetic provision and the other priority ESS of cooling of the urban heat island, habitat and wildlife corridor provision and public recreation and venue for green travel routes.

11.8 The Greater Manchester Health and Wellbeing Strategy highlights that tackling both child and adult mental health is the key to "unlocking the potential of Greater Manchester Communities". The strategy further highlights, especially with mental health issues, the importance of early interventions and preventions to avoid long term health and economic issues. In respect of ESS opportunity, and thus avoided cost, there is a strong driver for enhancing tree cover and encouraging interaction between people and semi-natural environments.

[31] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.
[32] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.

11.9 Where tree cover is low or where there are gaps in place making initiatives there are opportunities to improve the amenity ESS. Forestry Commission's recommendation is that urban tree canopy cover should be a minimum of 20%[33]. The tree cover statistics[34] relating to study areas within the IMC are provided in Table 17.

Table 17: Tree Canopy Cover

Study Area	Tree Canopy Cover (%)
Manchester	21.1
Oldham	16.9
Bolton	14
Bury	12.40
Heywood	8.3
Rochdale	7.8

11.10 Whilst Manchester is reaching this target, other towns in the IMC (where data is available) have a tree canopy cover below 20%.

Opportunity Assessment

11.11 ESS opportunities to enhance amenity arise on land where it is feasible to implement natural environment measures which:

- Increase tree canopy; and
- Create habitats which also add amenity value.

11.12 ESS opportunities arise where there is a need for greater amenity. Need in this case is defined by areas of low tree canopy cover. ESS opportunities close to recreation routes (Public Rights of Way and Greater Manchester or Lancashire Cycle Routes) are assumed to bring benefits to a greater number of people and can be used as a proxy indicator of need.

11.13 ESS opportunities for amenity are scored in terms of the attributes listed at Table 18.

Table 18: Ecosystem Service Opportunity Assessment for Amenity

Attribute	Score	Rationale
Tree Canopy Deficiency Areas (TCDA) - Greenspace	Green space parcels with 10% or less tree canopy score 1 (10% is chosen as a threshold for greenspaces since it is significantly below the Greater Manchester tree cover average)	The Greater Manchester tree canopy average is 16% where parcels of greenspace fall below this average there may be opportunities for tree planting to increase their amenity value. These parcels offer opportunities for additional tree planting to increase the tree canopy and habitat creation.

[33] https://www.charteredforesters.org/2017/06/urban-canopy-cover-england/
[34] http://www.urbantreecover.org/urban-forest-cover/

Attribute	Score	Rationale
Tree Canopy Deficiency Areas (TCDA) - Urban	Urban land parcels with 2% or less tree canopy score 1	(2% is chosen as a threshold for urban spaces, since these habitat types have inherently less capacity for supporting trees and most urban spaces are assumed to be capable of supporting at least 2% cover)
Placemaking	Land parcels with a PRoW or Cycle Route score 1	The presence of Greater Manchester and Lancashire PRoW and Cycle Routes indicates that people would come into contact with any placemaking interventions and such interventions would therefore have the greater benefit to people. Opportunities may include new waterfront access and habitat creation.

11.14 ESS opportunities in respect of amenity are mapped by land parcel. An amenity ESS opportunity heat-map is generated (see Figure 25).

Figure 25: Amenity ESS Opportunity Heat Map

Priority Interventions

11.15 Stakeholder interventions to improve ESS in respect of amenity will be of higher priority in the following scenarios:

- Publicly accessible waterfrontages – where community and business litter removal schemes are most effective;
- Waterbodies where the amenity ESS Opportunity score for land parcels has received the maximum score (i.e. 2 on the heat maps);
- In areas where IMD in respect of health are amongst the 20% poorest nationally; and
- Where the waterbody also scores well on the leisure and recreation and Ecological Networks opportunity maps; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.

Limitations and Areas for Further Development

11.16 Certain land typologies are excluded from the amenity ESS opportunity mapping because the types of interventions are not appropriate e.g. it would not be possible to plant trees on water or roads, nor would additional value be gained from planting trees in a woodland.

11.17 The attribute mapping for Tree Canopy Deficiency Areas is based on the OS MasterMap and Greater Manchester Tree Audit 2015-2017 (City of Trees) and tree planting projects since the data was produced may have already been implemented in areas flagged up as opportunities. As detailed in the data limitations section of the report the extent of the Greater Manchester Tree Audit is limited to Greater Manchester, future improvements for the project would include the extension of the tree mapping through purchase of data covering all of the study area. Likewise, the place making attribute mapping may include locations which have already been subject to access improvements.

Case Study: City of Trees

City of Trees is an innovative and exciting movement which aims to plant a tree for every man, woman and child that lives in Greater Manchester within a generation (approximately 3 million trees). So far, City of Trees has planted a total of 232,668 trees, 333 street trees and 68 orchards. It works in partnership with community groups, landowners, major businesses and reaches out in numerous different ways to further its influence.

For more information refer to: http://www.cityoftrees.org.uk/about-city-trees

12.0 Biodiversity and Ecological Networks

Value of the ESS in the Study Area

12.1 A monetary valuation of biodiversity and ecological networks has not been carried out in this study. The primary reason for this is the lack of agreement in the scientific and economic literature concerning accurate measurements of biodiversity and ecological networks and its contribution to processes that are important to human wellbeing. The economic valuation of biodiversity and ecological networks in itself would risk mis-specifying this integral function.

12.2 In addition, in a number of cases, biodiversity and ecological networks is likely to be valued in the delivery of other ESS, such as water quality and leisure and recreation. Thus, an attempt to value the biodiversity and ecological networks as an ESS risks double counting ESS benefits that have already been accounted for.

Issues

12.3 Ecological networks are the interaction between species and habitats and how they are connected. Previous studies, including Greater Manchester ESS Pinch Point Report[35], and the River Irwell Management Catchment – Evidence & Measures, Final Report February 2017[36], highlight the importance of biodiversity and ecological networks to the IMC.

12.4 The Greater Manchester ESS Pinch Point Report[37] includes habitat and wildlife corridor provision as one of Greater Manchester's eight priority ESS with the following 'pinches' (issues which need to be addressed to maximise ESS) identified:

- The need to work with private and public landowners to reverse the decline in levels of habitat management and take opportunities to connect up our ecological networks, particularly in the waterbodies which are our most substantial connected network;
- Influencing the management of private gardens, which are a major wildlife resource, and so could have significant wildlife and ESS benefits; and
- The need to work with those planning investments in growth, development and infrastructure to identify where key GI could be lost to development and therefore needs protecting, or where opportunities exist for new assets to be created though sensitive development.

12.5 The Greater Manchester ESS Pinch Point Report[38] summarises the strategic activities needed to maximise ESS benefits. For biodiversity and ecological networks, this includes:

- Public greenspaces: Better-managed, more multifunctional formal and informal public greenspaces;

[35] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.
[36] River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 for Greater Manchester Combined Authority
[37] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.
[38] GM Environment Team (2014) Greater Manchester Ecosystem Services Pinch Point study – draft final report prepared by the GM Environment team with support from Red Rose Forest and Countryscape.

- Rivers and canals: A more natural river network, with fewer culverted sections and greater capacity to store floodwaters. Canals that act as corridors for people and wildlife, that provide climate change adaptation, and support economic activity;
- River valleys: An integrated approach to managing the public greenspaces and private land in Greater Manchester's river valley network, with better linkages through them for people and wildlife;
- Trees and woodlands: More and better-managed woodlands and more trees in town centres, along transport corridors and in neighbourhoods where they are lacking;
- Mossland and moorlands better managed to retain and filter water and protect their carbon stores;
- Urban GI retrofitting: More street trees, soft landscaping, green roofs and walls and sustainable drainage built into the fabric of our urban areas; and
- Private gardens: Gardens with a greater proportion of permeable surfaces and more wildlife-friendly gardening practices.

12.6 The Report states that there is a strongly positive interaction between habitat and wildlife corridor provision and the other priority ESS of carbon storage and sequestration, cooling of the urban heat island, water quality management and visual/ aesthetic. It also highlights a negative interaction between habitat and wildlife corridor provision and local and commercial food production.

12.7 The River Irwell Management Catchment – Evidence & Measures, Final Report February 2017[39] has waterbody output maps showing measures that address water quality issues. Some of these measures, which involve habitat creation/improvement, would directly improve ESS related to ecological networks. The study also indicates whether any proposed projects fall within designated or important sites e.g. UK Biodiversity Action Plan (BAP)/ Priority Species/ Habitats and Sites of Biological Importance (SBI).

Opportunity Assessment

12.8 ESS opportunities to improve the functioning of ecological networks arise on land where it is feasible to implement natural environment measures which:

- Encourage expansion of priority habitats and designated sites onto surrounding land;
- Create buffering habitats around priority habitats and designated sites, which thereby reduce adverse effects of urbanisation or intensive agriculture; or
- Provide opportunities for the public to interact with semi-natural habitats.

12.9 ESS opportunities arise where there is a need to address ecological deficiency. Need in this case is defined by the Nature Improvement Areas (Nature Improvement Area Corridor, Nature Improvement Area Enhanced and Nature Improvement Area Farmland) identified and supplied by Greater Manchester Ecology Unit and the habitat corridors identified by Lancashire Environmental Network (LERN).

12.10 ESS opportunities for ecological networks are scored in terms of the attributes listed at Table 19.

[39] River Irwell Management Catchment – Evidence & Measures, Final Report February 2017 for Greater Manchester Combined Authority

Table 19: Ecosystem Service Opportunity Assessment for Ecological Networks

Attribute	Score	Rationale
Potential for re-wetting or wetland habitat creation	Land parcels potentially suitable for re-wetting score 1.	Soils and hydrology in these land parcels have greatest feasibility for wetland habitat restoration (wetlands being a Natural Course priority)
Proximity to habitats	Land parcels not currently supporting priority habitat score 1 if adjacent to priority habitat and score 2 if adjacent to designated sites. Parcels of priority habitats adjacent designated sites score 1.	It is widely recognised that species-richness is enhanced in larger habitat patches. Sensitive woodland flora is recognised to be vulnerable to spray drift and emissions at distances of up to 150m from source. Establishment of appropriate semi-natural habitat around existing patches will enhance species-richness and facilitate dispersal of mobile species
Nature Improvement Areas	Open land parcels within NIA's identified by GMEU or the LERN habitat network score 1	
Publically Accessible open space		Publically accessible open spaces offer opportunities for educational interactions with nature
Transport Corridors	Land parcels designated as transport corridors score 1.	Transport corridors are linear strips of land adjacent to roads, railway lines, and cycle paths. The mosaic of grassland, scrub, shelter belt and tall herb habitats usually associated with these transport corridors provide important refugia and wildlife links, facilitating the dispersal of plants and animals

12.11 ESS opportunities in respect of ecological networks are mapped by land parcel. An ecological network ESS opportunity heat-map is generated (see Figure 26)

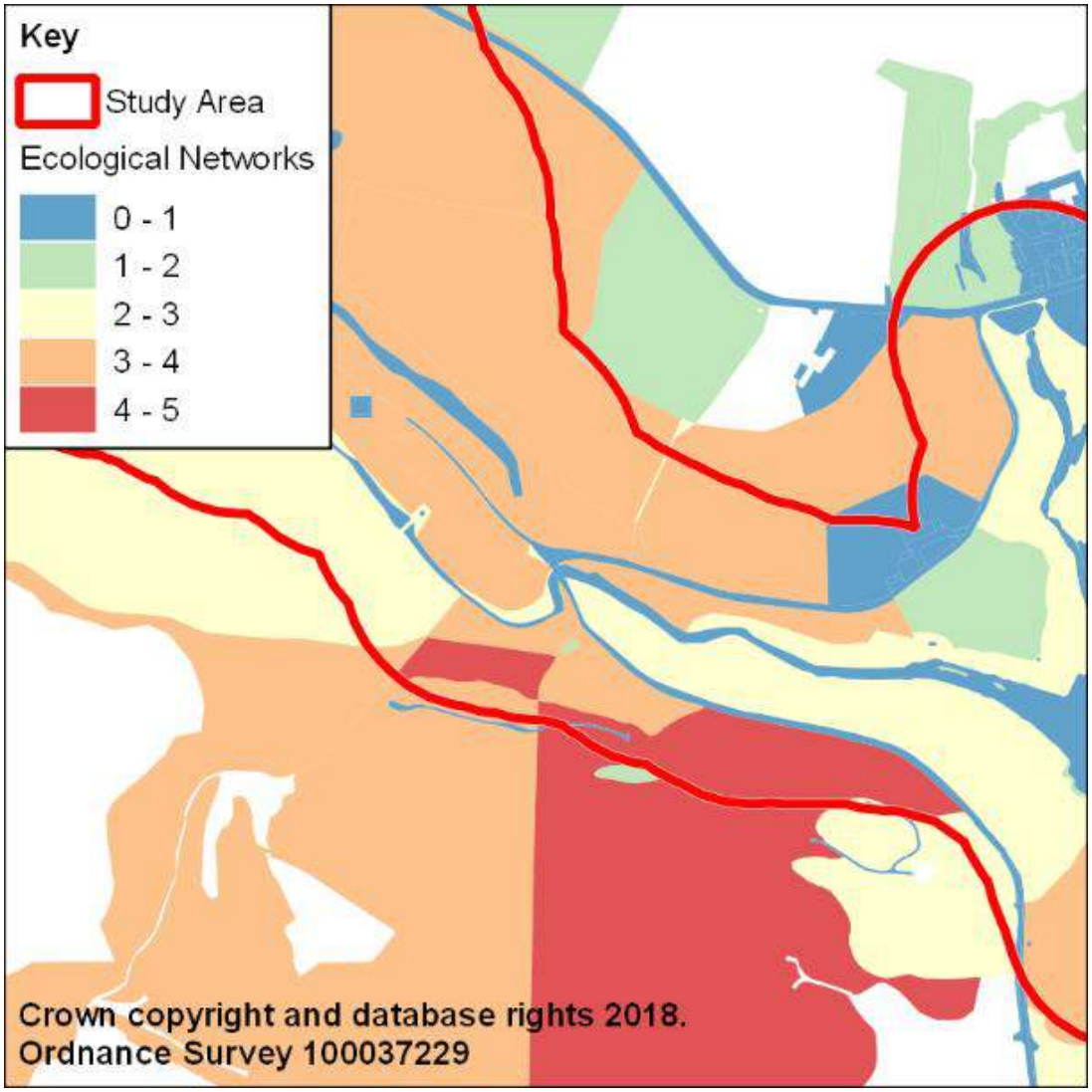


Figure 26: Ecological Networks Opportunity Heat Map

Priority Interventions

12.12 Stakeholder interventions to improve ESS in respect of ecological networks will be of priority in the following scenarios:

- In waterbodies scoring above average for the biodiversity and ecological networks ESS opportunity[40], as shown in Appendix H
- In land parcels scoring highly for amenity ESS opportunity, since this is likely to indicate a marked shortfall in tree canopy in areas close to centres of human habitation;
- Where the waterbody also scores well on the carbon sequestration and water quality opportunity maps; these opportunities require similar types of intervention

[40] Astley Brook (Irwell), Beal, Bradshaw Brook, Croal (including Blackshaw Brook), Eagley Brook, Folly Brook and Salteye Brook., Irk (Source to Wince Brook), Irk (Wince to Irwell), Irwell (Cowpe Bk to Rossendale STW), Irwell (Croal to Irk), Irwell (Roch to Croal), Irwell (Rossendale STW to Roch), Irwell (Source to Whitewell Brook), Irwell / Manchester Ship Canal (Irk to confluence with Upper Mersey), Kirklees Brook, Limy Water, Medlock (Lumb Brook to Irwell), Medlock (Source to Lumb Brook), Middle Brook, Naden Brook, Ogden, Roch (Source to Spodden), Roch (Spodden to Irwell), Spodden, Tonge, Whitewell Brook

and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.

- Where the land parcel (on investigation) is found to have invasive species that could be eradicated or has nearby protected/priority species whose territory could be expanded (the APEM Waterbody Output maps include this information); and
- Where the project would involve removal of weirs or barriers to fish migration (see the APEM Waterbody Output maps).

Limitations and Areas for Further Development

12.13 Currently there is no consistent IMC-wide open data on:

- Protected/priority species hotspots or recovery zones; and
- Invasive non-native species problem areas.

12.14 It is feasible for the former to be mapped and modelled by the Local Records Centre provided that issues of ownership and copyright of species records (which prevent free public release of this data) are overcome.

12.15 The presence of species data can be considered during development of an investment portfolio of Natural Course projects in the IMC, since field survey data is usually available from the relevant Local Records Centre on specific sites. If a project already scores highly for ESS opportunities, further weight would be added if it leads to species recovery or eradication of invasive species.

12.16 In a more rural catchment, land parcels adjacent to arable land or orchards might be scored for opportunity in respect of pollination support.

13.0 Air Quality

Value of the ESS in the Study Area

13.1 Modelling the effect of vegetation on air pollution is complicated by scientific uncertainty about the rates of absorption and disposition of particulates by different types of vegetation. This makes it difficult to approximate the biophysical models that underlie the ESS valuation. More complex and expensive modelling techniques are required to credibly estimate the contribution of vegetation to improvements in air quality by simulating air quality under counterfactual vegetation scenarios. This study does not value the contribution natural capital plays in mitigating air pollution. 'A Study to Scope and Develop Urban Natural Capital Accounts for the UK[41]' provides preliminary estimates of the value natural capital plays in mitigating air pollution.

Issues

13.2 In Greater Manchester, the air quality priorities as set out in the Greater Manchester Air Quality Action Plan (AQAP) 2016-2021[42] relevant to waterbodies relate to improvement of cycle infrastructure, promotion of cycling and walking, and encouragement of travel choices. The waterbodies offer linear corridors, some of which link centres of population and commerce, and can form the backbone of alternative travel routes.

13.3 Greenspaces relatively close to main road corridors can provide relief from high concentrations of pollutants. The AQAP notes that properties within 25m of a road are at the highest risk. Displacement of active travel into a green corridor can provide immediate relief, along with the possibility of some absorption of particulates by foliage.

Opportunity Assessment

13.4 For this study, ESS opportunities in waterbody corridors in respect of air quality arise on land where it is feasible to displace cycling and walking away from main roads in Greater Manchester's air quality priority areas. ESS opportunities for air quality scored in terms of the attributes listed at Table 20.

[41] http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19843

[42] GMCA (2018) Greater Manchester Air Quality Action Plan 2016-2021

Table 20: Ecosystem Service Opportunity Assessment for Air Quality

Attribute	Score	Rationale
Modelled Background Pollution Data PM2.5 Distribution	Land parcels which intersect with areas of 10 µg/m^3 PM 2.5 distribution or higher score 2. Land parcels which intersect with areas of 8 to 10 µg/m^3 PM 2.5 distribution score 1. Land parcels which intersect with areas of less than 8 µg/m^3 PM 2.5 distribution score 0.	Medical evidence shows that many thousands of people still die prematurely every year because of the effects of air pollution. Air pollution from man-made particles is currently estimated to reduce average UK life expectancy (from birth) by six months. Moreover, it is now firmly established that air pollution (particulate matter, sulphur dioxide and ozone) contributes to thousands of hospital admissions per year
Number of Primary Roads within Waterbody Catchment	Land parcels within catchments that contain over 27 primary roads score 3, 11- 27 score 2 and less than 11 score 1.	Identifying Waterbody catchments that contain the highest number of primary roads (A, B, and Primary classified roads). Catchments with the highest number of roads potentially have more opportunity to displace cycling, running, walking commutes from roads to greenspaces or green routes.

13.5 ESS opportunities in respect of air quality are mapped by land parcel. An air quality ESS opportunity heat-map is generated (see Figure 27).

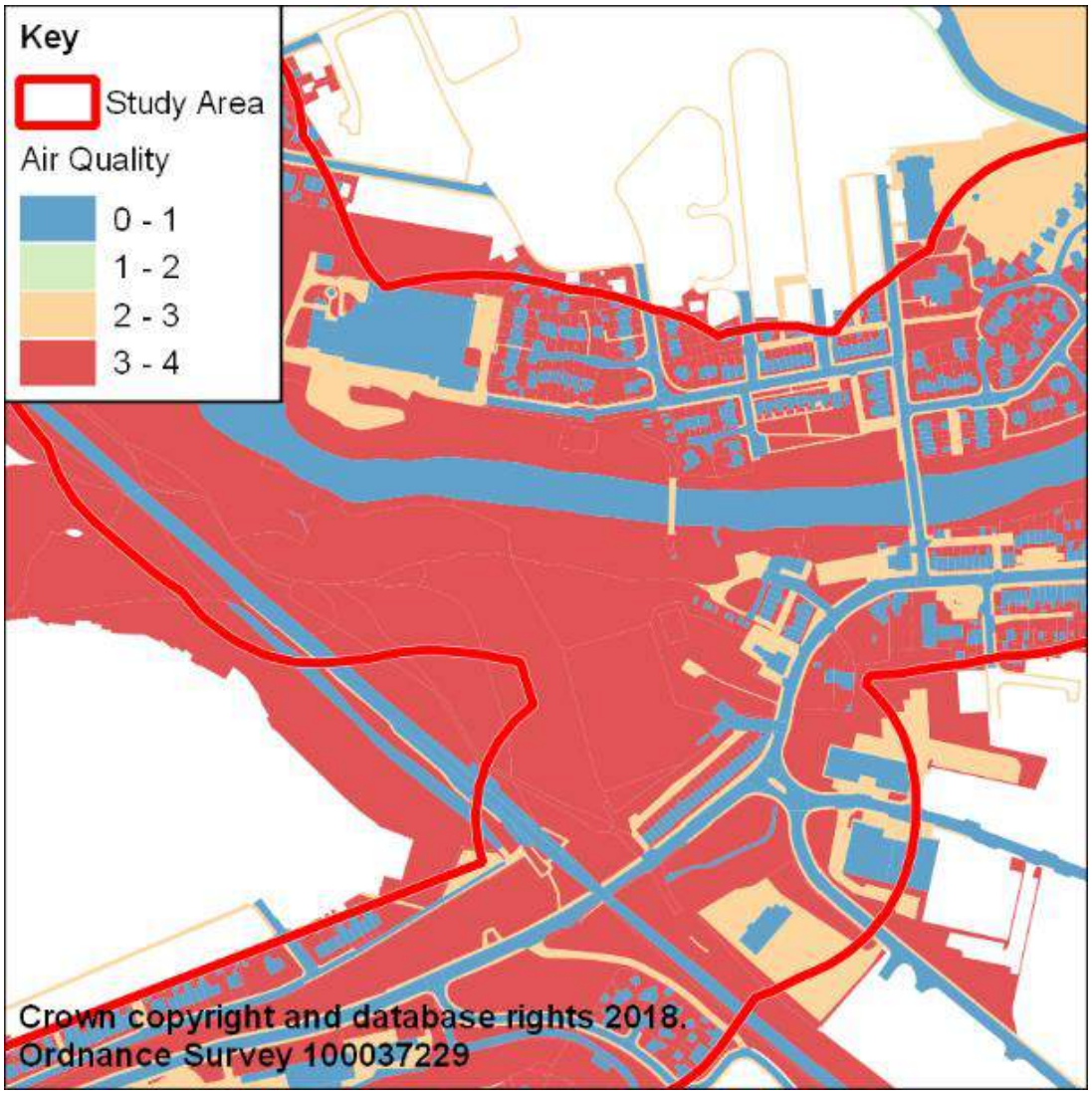


Figure 27: Air Quality Opportunity Heat Map

Limitations and Areas for Further Development

13.6 This study has focussed on travel displacement, but it is likely that ongoing national research into the effectiveness of foliage to mitigate atmospheric pollutants will identify specific opportunities that may apply to the study area. Currently the Greater Manchester AQAP 2016-2021 only suggests the use of green screens in certain situations such as schools.

Priority Interventions

13.7 Stakeholder interventions to improve ESS in respect of air quality will be of higher priority in the following scenarios:

- In larger greenspaces, (Figure 28 shows clustered greenspaces over 20ha) where it is most likely that a significant shift of pedestrians and cyclists away from roads can be achieved;
- In areas where IMD in respect of health are the 20% poorest nationally; and

- Waterbodies prioritised under leisure and recreation (including Health) opportunity; these opportunities require similar types of intervention and benefits are likely to spread across several ESS, thereby increasing the spread of funding and delivery partners.

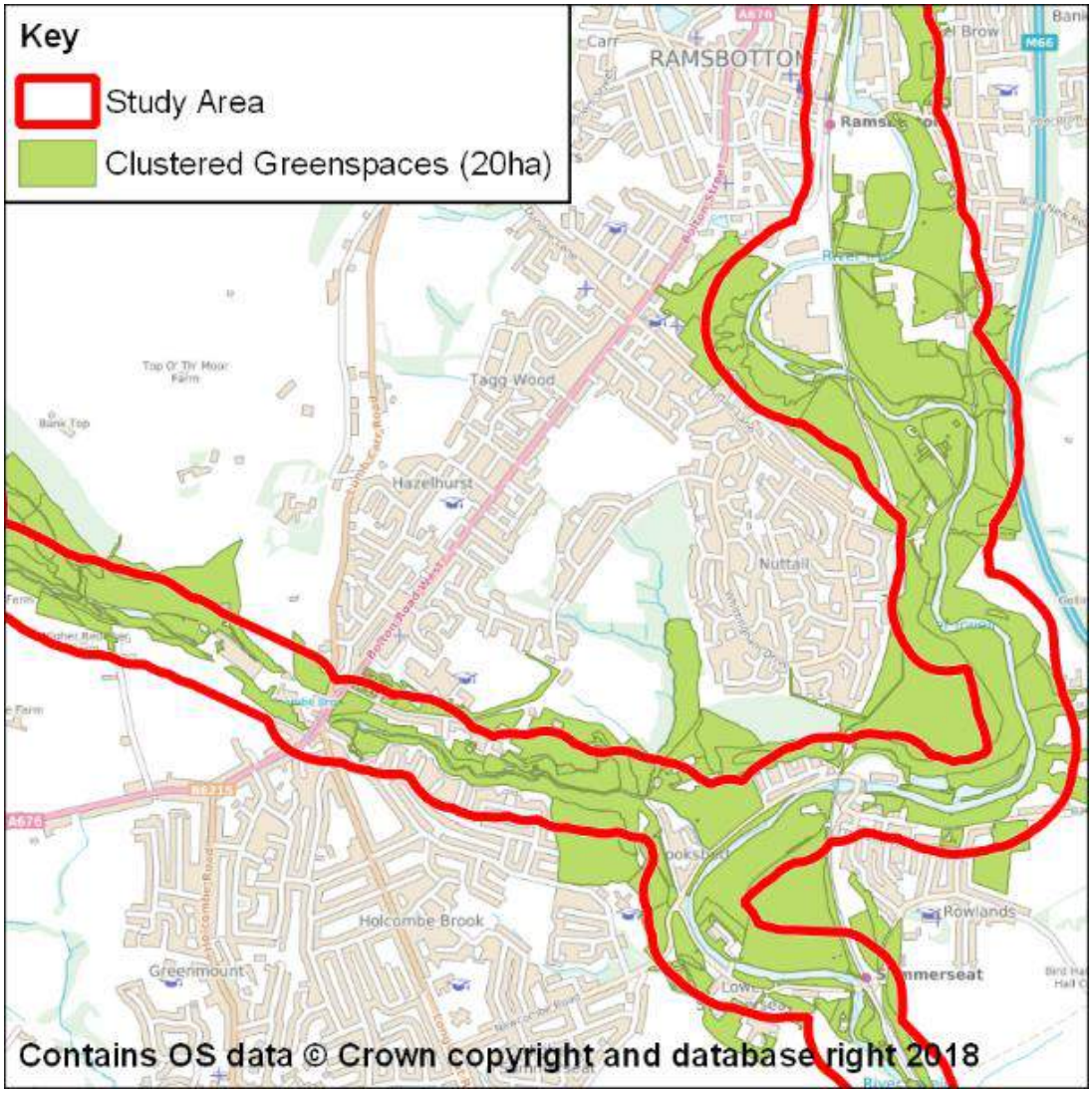


Figure 28: Clustered Greenspaces > 20ha

Case Study: Bridgewater Canal Towpath Enhancement

The Bridgewater Canal towpath in Sale was upgraded in 2016 with resurfacing and localised widening. The works have provided a safe, surfaced and traffic-free waterside route for walkers and cyclists. Trafford Council has reported an increase in cycling of around 380% as result of the upgrade to 5km of towpath within its administrative boundary. Part of this will comprise cycling commuter travel, with a likely displacement of travel from nearby main roads. The improvement works formed part of the Bridgewater Way project led by Bridgewater Canal Trust landowners Peel, alongside the Canal and Rivers Trust and seven local authorities with the aim of making the towpath along the length of the Bridgewater Canal between Runcorn, Leigh and Manchester City Centre (65km in total) accessible to 5 million people. The Bridgewater Way will cost approximately £8 million.

For further information refer to:

http://www.trafford.gov.uk/residents/leisure-and-lifestyle/sport-and-leisure/cycling/bridgewater-way.aspx

http://www.bridgewatercanal.co.uk/media/BWWPAGES.pdf

14.0 Noise Reduction and Temperature Regulation

Value of the ESS in the Study Area

Noise Reduction

14.1 The mitigating effect that vegetation has on noise pollution is an important functioning of natural capital in urban areas owing to the adverse effects of excess noise on sleep and increased levels of stress.[43] Estimation of the noise attenuating effect of vegetation is, however, underpinned by complex spatial models of emitters of noise pollution, mitigating factors, and the population affected by varying levels of noise. Physically modelling these factors is beyond the scope of this study and publicly available models do not currently exist.[44] This study does not value the contribution natural capital plays in mitigating noise. 'A Study to Scope and Develop Urban Natural Capital Accounts for the UK[45]' provides preliminary estimates of the value natural capital plays in mitigating noise pollution.

Temperature Regulation

14.2 Existing models of the cooling effect of vegetation are employed at a range of different geographical levels.[46] An example of the economic impact of vegetation on urban cooling is estimated at the city-level for London.[47]

14.3 The spatial resolution of this study is extremely large and does not factor in localises differences in air temperature. A downside of more localised models of temperature mitigation is that they are computationally intensive and require detailed knowledge about the spatial relationship between vegetation types and the temperature of surrounding atmosphere.

14.4 Use of the Surface Temperature and Runoff (STAR) tool, which can be used at a neighbourhood scale (in the North West of England and beyond) to test the impact of different land cover scenarios under different temperature and precipitation scenarios was considered. A weakness of the tool, however, is that predicted temperature is an average value for each study area. It is suggested that a city or local authority level would be too large, whilst a street or a couple of buildings may be too small. Application of this tool to this project is thus limited by uncertainty about optimal study area size, non-replicability of tool over of multiple locations and uncertainty over the correct land cover scenarios to yield meaningful assessment of natural capital role in temperature regulation.

[43] https://www.gov.uk/guidance/noise-pollution-economic-analysis

[44] Recent estimates of the impact that clusters of trees (greater than 200 m²) have on reducing noise pollution have recently been analysed for Greater Manchester: The analysis within this is undertaken by estimating how much noise is mitigated using spatial noise maps and house location data to identify beneficiaries. At this report's time of writing, detailed results of this study were not available. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19843.

[45]http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19843

[46] https://www.sciencedirect.com/science/article/pii/S0048969717301754

[47] https://www.forestry.gov.uk/pdf/LONDONI-TREEECOREPORT151202.pdf/$FILE/LONDONI-TREEECOREPORT151202.pdf

Opportunity Assessment

14.5 These ESS have not been subject to opportunity mapping as part of this study. In part this is due to the need for further research on valuation, as described above.

14.6 Opportunity mapping at a fine-grained scale may not be appropriate for these ESS, since the feasibility of natural capital interventions at a specific place delivering specific noise reduction or temperature regulation at an immediately adjoining receptor is not fully proven.

14.7 There is also insufficient data on ambient noise and temperature conditions to identify priority areas systematically and at a granular level across the IMC.

14.8 This is not to undervalue the benefits of natural capital interventions in terms of these ESS. It is likely that natural capital projects in areas highlighted by the ESS opportunity maps for leisure and recreation, amenity and air quality, will also bring noise reduction and temperature regulation benefits to local communities.

14.9 At project design stages, site-specific assessments can look for opportunities to deliver noise reduction and/or local shading or wind-reduction benefits.

15.0 Agriculture (Food Production) and Timber Production

Value of the ESS in the Study Area

Agriculture (Food Production)

15.1 Agriculture is the dominant land use around the waterbodies within the IMC. This is particularly the case in the north of the IMC, where pasture land is used as grazing land for livestock. The economic value provided by land within the study area is estimated at £950,000 per year. This figure reflects the amount of land devoted to agriculture and profitability of a representative parcel of farm land in the area.

Table 21: Breakdown of the Value of Agriculture (Food Production) within the Study Area

Variable	Unit
Area of agricultural land in waterbody corridors (hectares)	5,127ha
Value of agricultural production	£950,000

15.2 It is assumed that agricultural land is made up of 50% Less Favoured Area (LFA) grazing livestock farm and 50% lowland grazing livestock farms. The per hectare farm business income is taken from the Farm Management Handbook 2016/17 and refers to the difference between farm gross margin and fixed production costs.

Timber Production

15.3 Wooded areas offer economic opportunities for the harvesting of timber, which can raise revenue for owners of woodland. The value of timber production currently provided by woodland in the IMS is calculated using data derived from the Forestry Commission on stocked area of woodland and evidence of management activities.[48]

15.4 The annual value of timber production provided by woodlands around the waterbody corridors totals £140,000. The majority of this revenue is earned from softwood (coniferous) trees, as the deciduous woodland in the IMC has little current forest management. Values for timber production are not mapped across the IMC since the exact locations of woodlands that are harvested on an annual basis are not recorded.

Table 22: Breakdown of the value of Timber Production within the Study Area

Variable	Unit
Area of woodland in waterbody corridors	2,500ha
Estimated volume of softwood timber available annually	5,000m³/year
Estimated volume of hardwood timber available annually	1,100m³/year
Value of standing timber	£140,000

48 https://www.forestry.gov.uk/pdf/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf/$FILE/50_YEAR_FORECAST_OF_SOFTWOOD_AVAILABILITY.pdf

15.5 Data on the timber availability per amount of woodland and timber in the IMC was provided by the Forestry Commission. Forecasts of timber availability rely on sampling techniques about woodland characteristics and management activities. Softwood and hardwood prices are for the value of standing timber and are assuming to reflect resource rents given the low marginal costs after planting.

Opportunity Assessment

15.6 In regards to agriculture (food production), it is very unlikely that there will be land parcels within the study area that are currently non-agricultural land use that would be converted to commercial farming. Opportunities for expanding agricultural land use have not been mapped as it would be impossible to develop criteria about which parcels of currently mapped as greenspace or urban could be converted to agriculture.

15.7 The 25 Year Environment Plan envisages farming support in future may become more aligned with natural capital activities so the sector may be able to derive greater value from measures to enhance soil conservation and water quality protection.

15.8 As Chapter 4 indicates, there is relatively little allotment land in the study area, and there would be opportunity for significant uplift in this land use, which whilst not significant in terms of natural capital value associated with food production, would uplift natural capital value in relation to leisure and recreation and health ESS.

15.9 In relation to timber production ESS opportunities, there is no specific map. Most existing woods offer some opportunities to improve timber out-turns, although most woods in the study area are currently designated for ecological value, which may constrain the ease of planning for timber extraction. Other mapped opportunities for amenity, water quality, flood risk mitigation ESS would involve tree-planting, and in most cases, it would be possible to use productive broadleaf and (in mixture) coniferous species, thereby increasing timber production ESS.

16.0 Next Steps

16.1 The key outcome of this Assessment is to support the IMC Partnership and other key stakeholders in the identification and development of projects. The following steps set out how the outputs from the study can be used to inform project development and how these projects can form part of an investment portfolio.

Advocacy and Policy Development

16.2 This study can be used as evidence to direct spatial planning and community infrastructure funding. Examples of this are provided below.

- Developers of Projects:
    - A developer of a project will identify potential project areas or sites in line with their objectives. This assessment (and the associated methodology) will enable the evaluation of specific proposals based on their impacts (positive and negative) on natural capital, and model the effect of different scenarios.
    - Developers of projects may find Appendix G and H most useful as they show the Natural Capital Accounts by waterbody (and by district) and the ESS opportunity assessment data for each of the 27 waterbodies within the IMC, respectively.

- Formulating Local Plans:
    - Planners could use this assessment to gain an understanding of the distribution of current benefits to inform future spending plans and priorities.
    - Planners could also use this assessment to identify specific sites for future development in line with priorities around equity.
    - Offsetting policies and funds associated with development in the IMC (e.g. biodiversity and ecological networks, carbon sequestration and emerging ESS offsets) can then be directed towards projects which deliver an equivalent ESS uplift in an IMC waterbody.
    - Planners could utilise Appendix H and I which provide the ESS opportunity assessment data for each of the 27 waterbodies within the IMC and the ESS valuations and opportunities by district, respectively.

- Water Stakeholders:
    - Utility and Infrastructure providers who rely on waterbodies in the IMC can adjust their long-term asset management plans towards sustaining natural capital values. In some cases, this can provide a direct commercial benefit e.g. hydro-electric generation or avoiding costs associated with sediment removal.
    - Similarly, water stakeholders who manage waterbodies and surrounding land may use this Assessment to identify opportunities for the use of water for energy generation (as above).
    - Key water stakeholders may also use the Assessment to identify opportunities for integrated water quality and green space management.
    - Appendix G, H and I which show the Natural Capital Accounts by waterbody and district, the ESS opportunity assessment by waterbody

and the ESS valuations and opportunities by district, respectively, will assist water stakeholders.

- Informing Catchment Partnership Projects:
    - Partnerships can be developed with health and social care providers to joint-fund projects which improve physical and mental health through participation in outdoor activity.
    - Many stakeholders within the Partnerships act as owners of key assets, managers of assets and/or beneficiaries of services.
    - The Natural Capital Account can provide a focal point to structure discussions about funding arrangements and management strategies. It can also be used to inform potential partnerships in the IMC e.g. to engage partners in the healthcare sector.
    - Appendix H which provides the ESS opportunity assessment data for each of the 27 waterbodies within the IMC will be particularly useful in these scenarios.

- Volunteers:
    - Citizen involvement in project development can be stimulated through the display of ESS opportunity and Natural Capital Account on the MappingGM website.
    - Appendix H may also be useful to volunteers as it provides the ESS opportunity assessment data for each of the 27 waterbodies within the IMC.

Prioritisation and Development of Projects

16.3 The results of this study's Natural Capital Account and ESS Opportunity Mapping can help lay the foundations for managing natural capital in a way that maximises the economic value of ESS to people.

16.4 The Natural Capital Account and the ESS Opportunity Mapping can be brought together to help the IMC Partnership and other key stakeholders identify priority areas for investment.

16.5 Waterbodies can be ranked in terms of both the current provision of natural capital and the total opportunity score for each ESS. The overlap between natural capital provision and opportunities helps to identify locations that fall in different categories of prioritisation.

16.6 Table 23 is a matrix which shows four categories of waterbody:

Waterbodies Where Both Natural Capital Value and ESS Opportunity are Above Average (Orange Cells)

16.7 These are typically urban waterbodies and represent critical natural infrastructure that must be maintained owing to the high demand for natural capital in a densely populated area. The priority of future investment is to maintain existing natural capital value and develop new projects which address specific environmental problems or meet the specific health needs of local communities. These waterbodies are:

- Irwell (Croal to Irk);
- Irwell/ Manchester Ship Canal (Irk to confluence with Upper Mersey);

- Medlock (Lumb Brook to Irwell);
- Medlock (Source to Lumb Brook);
- Roch (Source to Spodden);
- Roch (Spodden to Irwell); and
- Tonge.

Waterbodies Where Natural Capital Value is Lower than Average but ESS Opportunity is High (Yellow Cells)

16.8 These are typically urban waterbodies or urban/rural fringe waterbodies upstream of communities which experience flood risk and/or deprivation concerns. These waterbodies be considered as critical environmental infrastructure with gaps and weaknesses that can be tackled (at least in part) by investment in the natural environment. The policy priority is to create and enhance GI. These waterbodies are:

- Bradshaw Brook;
- Croal (including Blackshaw Brook);
- Irwell (including Roch to Croal)
- Irwell (Rossendale STW to Roch)
- Kirklees Brook;
- Middle Brook;
- Naden Brook; and
- Ogden.

Waterbodies Where Natural Capital Value is Above Average but ESS Opportunity is Below Average (Blue Cells)

16.9 These tend to be urban or fringe waterbodies and some sustain large populations. They are also critical natural infrastructure. Whilst these waterbodies have fewer opportunities for widespread new GI projects, they require continuing investment to maintain their natural capital value and also implement specific ESS opportunities that can tackle local deficiencies in natural capital. Interventions in these areas may have to be carefully selected in order to maintain current environmental quality. These waterbodies are:

- Folly Brook and Salteye Brook;
- Irk (Wince to Irwell);
- Limy Water; and
- Spodden.

Waterbodies Where Both Natural Capital Value and ESS Opportunity are Below Average (Grey Cells)

16.10 These waterbodies tend to have lower populations dependent on them. Whilst they will generally be lower priorities for a strategic investment portfolio, nevertheless most have specific ESS opportunities that merit consideration, and there will be locally significant issues to tackle. These waterbodies are:

- Astley Brook (Irwell);
- Beal;
- Eagley Brook;
- Irk (Source to Wince Brook);
- Irwell (Cowpe Bk to Rossendale STW); and
- Whitewell Brook.

16.11 For stakeholders with an interest in a specific ESS, the matrix also enables identification of current value and opportunity for that ESS. For example, stakeholders with specific interest in biodiversity and ecological networks, water quality and carbon sequestration (which are typically conflated aspirations) can identify waterbodies highlighted in orange and yellow for these ESS.

16.12 The matrix should of course be read alongside the detailed ESS opportunity mapping and other Natural Course documents to identify an investment portfolio, and proposals would require ground-truthing and local consultation before being refined into a costed portfolio.

Project Development

16.13 The current work provides a baseline assessment of the sources of natural capital around waterbodies in the IMC. Prioritisation of project areas can be informed by comparing current provision of services with opportunities for improvements. The next step would be to build a framework to evaluate site-specific investment options, incorporating capital costs and changes in natural capital value.

Natural Capital Investment Plan

16.14 This study has provided a solid evidence base for the Natural Capital base line accounts and ESS opportunities for the River Irwell Catchment. Looking forward to stages 2 and 3 of Natural Course, the study provides a valuable starting point for progress towards implementing actions throughout the catchment.

16.15 It will be important when looking ahead to prioritising investments and projects that a clear and informed Investment Prospectus is developed including the means of delivering projects and identifying funding arrangements and possible collaborations and partnership working.

16.16 Once an Investment Prospectus is developed, there is potential to develop a fully evidenced and costed Natural Capital Investment Plan, which can provide details on the impacts and benefits to ESS and Natural Capital from potential delivery programs.

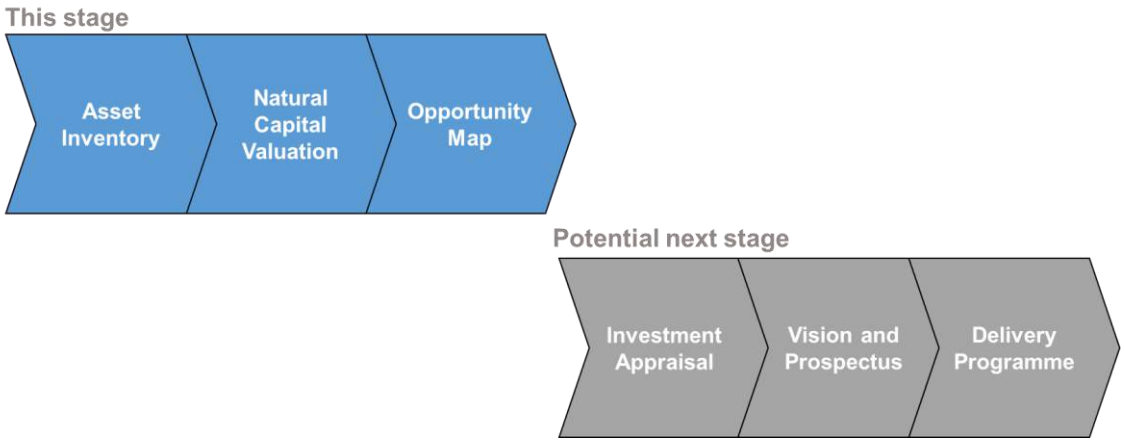


Table 23: Natural Capital Value and Ecosystem Service Opportunity Matrix

Catchment Name	Population	Total Natural Capital	Per Head	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk Mitigation	Water Abstraction	Agriculture (Food Production)	Biodiversity and Ecological Networks	Air Quality
Astley Brook (Irwell)	30,000	£2.9m	£97											
Beal	37,000	£7.6m	£205											
Bradshaw Brook	34,000	£7.1m	£209											
Croal (including Blackshaw Brook)	55,000	£10m	£182											
Eagley Brook	24,000	£3.6m	£150											
Folly Brook and Salteye Brook.	62,000	£21m	£339											
Irk (Source to Wince Brook)	68,000	£14m	£206											
Irk (Wince to Irwell)	120,000	£45m	£375											
Irwell (Cowpe Bk to Rossendale STW)	8,200	£560k	£68											
Irwell (Croal to Irk)	120,000	£56m	£467											
Irwell (Roch to Croal)	41,000	£11m	£268											
Irwell (Rossendale STW to Roch)	42,000	£11m	£262											
Irwell (Source to Whitewell Brook)	9,500	£2.5m	£263											
Irwell / Manchester Ship Canal (Irk to confluence with Upper Mersey)	250,000	£70m	£280											
Kirklees Brook	17,000	£3.4m	£200											
Limy Water	7,200	£2.1m	£292											
Medlock (Lumb Brook to Irwell)	100,000	£34m	£340											
Medlock (Source to Lumb Brook)	120,000	£26m	£217											
Middle Brook	79,000	£13m	£165											
Naden Brook	6,500	£1.3m	£200											
Ogden	11,000	£1.2m	£109											

Catchment Name	Population	Total Natural Capital	Per Head	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk Mitigation	Water Abstraction	Agriculture (Food Production)	Biodiversity and Ecological Networks	Air Quality
Roch (Source to Spodden)	57,000	£15m	£263											
Roch (Spodden to Irwell)	93,000	£20m	£215											
Spodden	25,000	£14m	£560											
Tonge	14,000	£4.6m	£329											
Whitewell Brook	14,000	£2.2m	£157											

Notes

£	*Grey highlighted cells indicate that both the natural capital value and the ESS Opportunity Ranking is below average.*
£	*Blue highlighted cells indicate that the natural capital value is above average but the ESS Opportunity Ranking is below average.*
£	*Yellow highlighted cells indicate that the natural capital value is below average but the ESS Opportunity Ranking is above average.*
£	*Orange highlighted cells indicate that both the natural capital value and ESS Opportunity Ranking is above average.*

Figures are rounded to 2 significant figures
Timber production value is excluded since information is not available at waterbody level
Biodiversity and ecological networks and air quality are not valued, but waterbodies with above average ESS Opportunity ranking are highlighted orange
Natural capital values are given as £/year

APPENDIX A: MASTER DATASETS

Appendix A: Master Datasets

The following technical appendix details all datasets utilised for all key stages of the project including: habitat mapping, Natural Capital Accounts and ESS opportunity mapping. Where possible, national open source datasets have been utilised to enable the methodology to replicated for other river valley or catchment assessment.

The table within this appendix details all datasets including:

Data: Reference name for dataset.

Source: Source organisation for dataset.

Coverage: The geographic coverage of dataset.

Licence: Any licence agreement requirements.

Usage: Detailing which elements of the project the data has been used for.

Notes: Details relating to any outstanding issues or attributed information.

Data	Source	Coverage	Licence	Usage	Notes
2m LIDAR Digital Terrain Model (DTM)	Environment Agency (EA): http://environment.data.gov.uk/ds/survey/index.jsp#/survey	National (Limited Areas)	Open Government Licence	• Opportunity	Limited coverage in areas. Areas of the eastern catchment are missing. EA announced that it will have complete UK coverage by 2020[1].
Risk of Flooding from Rivers or Sea (RoFRS)	EA: https://data.gov.uk/dataset/risk-of-flooding-from-rivers-and-sea1	National	Open Government Licence	• Opportunity • Valuation	
Water Body Catchments	EA: http://environment.data.gov.uk/catchment-planning/	National	Open Government Licence	• Opportunity	
Water Framework Directive – River & Canal Status 2016 Cycle 2	EA	National	Open Government Licence	• Habitat mapping • Opportunity	Client supplied.
Consented Discharges With Conditions	EA: https://data.gov.uk/dataset/consented-discharges-to-controlled-waters-with-conditions	National	EA Conditional Licence	• Opportunity	
Detailed River Network	EA	National	Assumed - Public Sector Mapping Agreement	• Habitat mapping • Opportunity	Client supplied. Detailed river network is being depreciated in favour of the OS

[1] https://environmentagency.blog.gov.uk/2017/12/30/uncovering-englands-landscape-by-2020/

					MasterMap Water Layer.
Modelled Background Pollution Data	Defra: https://uk-air.defra.gov.uk/data/pcm-data	National	Open Government Licence	• Opportunity • Valuation	
Drinking Water – Surface Water Safeguard Zones	EA: https://data.gov.uk/dataset/drinking-water-safeguard-zones-surface-water	National	EA Conditional Licence	• Opportunity • Valuation	
Drinking Water – Ground Water Safeguard Zones	EA: https://data.gov.uk/dataset/drinking-water-safeguard-zones-groundwater	National	EA Conditional Licence	• Opportunity • Valuation	
Drinking Water – Surface Water Protected Areas	EA: https://data.gov.uk/dataset/drinking-water-protected-areas-surface-water	National	EA Conditional Licence	• Opportunity • Valuation	
Areas to Benefit – Capital Schemes (Green and Amber) Polygons	EA: https://data.gov.uk/dataset/areas-to-benefit-capital-schemes-green-and-amber-polygons	National	EA Conditional Licence	• Opportunity	Indicative only, historic dataset.
Areas to Benefit – Capitol Schemes (Red) Points	EA: https://data.gov.uk/dataset/areas-to-benefit-capital-schemes-red-points	National	EA Conditional Licence	• Opportunity	Indicative only, historic dataset.
Nitrate Vulnerable Zones	EA: https://data.gov.uk/data/search?q=Nitrate+Vulnerable+Zones+%28NVZ%29+2017+-&publisher=environment-agency	National	Open Government Licence	• Opportunity	
Drinking Water Abstraction Points	United Utilities (UU)	GM	Conditional Licence	• Opportunity • Valuation	**Data is confidential.**

					Locations cannot be revealed in any mapping, reporting, publication, or onward distribution.
Catchment Based Approach (CaBA) – Data Packages, Irwell Catchment • Phase 1 • Phase 2 • Phase 3	The Rivers Trust	England	Conditional Licence	• Opportunity • Valuation	Client supplied.
Crop Map of England (CROME)	Rural Payments Agency https://data.gov.uk/publisher/rural-payments-agency	England	Open Government Licence	• Habitat mapping • Opportunity	Crop accuracy varies and is noticeable wrong in some areas, coverage is limited to hexagonal polygons.
Ordnance Survey MasterMap Topography Layer	Ordnance Survey (OS)	National	Commercial / Public Sector Mapping Agreement (PSMA)	• Habitat mapping • Opportunity • Valuation	Client supplied. Unless available under PSMA, can be prohibitively expensive for large areas. E.g. Irwell Catchment approx. £50k
Ordnance Survey Vector Map Local	OS	National	Open Government Licence	• Opportunity	
Ordnance Survey MasterMap Greenspace	OS	National	PSMA	• Habitat mapping • Opportunity	Client supplied. National coverage, but limited (by design) to populated areas, such as towns and cities.

Ordnance Survey AddressBase	OS	National	PSMA	• Habitat mapping • Opportunity	Client supplied.
Ordnance Survey Open Greenspace	OS: https://www.ordnancesurvey.co.uk/opendatadownload/products.html#OPGRSP	National	Open Government Licence	• Habitat mapping • Opportunity	
Ordnance Survey Open Rivers	OS: https://www.ordnancesurvey.co.uk/opendatadownload/products.html#OPRVRS	National	Open Government Licence	• Habitat mapping • Opportunity	
CORINE Land Cover	European Environment Agency	Europe	EU - Full, Free & Open Access	• Habitat Mapping • Opportunity	Data resolution is coarse.
European Soil Database v2.0	European Soil Data Centre - EU: http://eusoils.jrc.ec.europa.eu/content/european-soil-database-v20-vector-and-attribute-data	Europe	Non-commercial	• Opportunity	Data resolution is very coarse. If data budget allowed, purchasing the National Soil Map, would add higher resolution data. £2k+ estimated.
Ecological Designations • SSSI • SPA • SAC • Ramsar • Ancient Woodland • Priority Habitat Inventory • Registered Parks & Gardens • Scheduled Monuments • Local Nature Reserves	Natural England (NE) – MAGIC: http://www.natureonthemap.naturalengland.org.uk/Dataset_Download_Summary.htm	England	Open Government Licence	• Habitat mapping • Opportunity	

• National Nature Reserves • Areas of Outstanding Natural Beauty • National Parks • Agricultural Land Classification					
National Forest Inventory	Forestry Commission (FC): http://data-forestry.opendata.arcgis.com/	England	Open Government Licence	• Habitat mapping • Opportunity	
Local Designations • Biological Heritage Sites	Lancashire Environment Record Network (LERN): http://www.lancashire.gov.uk/lern/site-designations/local-sites/biological-heritage-sites.aspx	Lancashire	Conditional Licence	• Opportunity	Lancashire only.
Local Designations • Site of Biological Importance	Greater Manchester Ecology Unit (GMEU): https://data.gov.uk/dataset/sites-of-biological-importance-sbi-in-greater-manchester	GM	Open Government Licence	• Opportunity	GM only.
Nature Improvement Areas • Corridor • Enhancement Layer • Farmland	GMEU	GM / South Lancashire	Conditional Licence	• Opportunity	Client supplied.
Green Infrastructure Typologies	GMEU	Manchester	Conditional Licence / PSMA	• Habitat mapping • Opportunity	Client supplied. Area limited to Manchester, not the Irwell catchment.
Strategic Development Sites (Housing, Office, Industrial)	GMCA	GM	Conditional Licence	• Opportunity	Client supplied.

Brownfield Sites	GMCA	GM	Conditional Licence	• Opportunity	Client supplied.
Cycle Routes (Greater Manchester)	Transport for Greater Manchester (TfGM): https://data.gov.uk/dataset/gm-cycle-routes	GM	Open Government Licence	• Opportunity	Contains more cycle routes, networks & links than Sustrans Cycle Routes data.
Sustrans Cycle Networks	Sustrans	Irwell Catchment	Conditional Licence / Ordnance Survey	• Opportunity	Client supplied. Differs from the cycle routes provided by TfGM. Queried with Sustrans, response not received.
Public Rights of Way (Greater Manchester)	GMCA	GM	Conditional Licence	• Opportunity	Client supplied.
Public Rights of Way (Lancashire)	Lancashire County Council (LCC)	Lancashire	Conditional Licence	• Opportunity	Client supplied.
Middle Layer Super Output Areas / Lower Layer Super Output Areas	Office for National Statistics (ONS): https://data.gov.uk/publisher/office-for-national-statistics	National	Open Government Licence	• Opportunity • Valuation	
Indices of Multiple Deprivation	ONS: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015	National	Open Government Licence	• Opportunity • Valuation	
Greater Manchester ESS Pinch Point Report	NE and GMCA	GM	Conditional Licence	• Habitat mapping • Opportunity	Client supplied.
Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments	Manchester City of Trees	GM	Conditional Licence	• Habitat mapping • Opportunity	Client supplied
Greater Manchester Tree Audit	Manchester City of Trees	GM	Conditional Licence	• Opportunity • Valuation	

Natural Flood Risk Management Working With Natural Processes, Opportunity Mapping	The Rivers Trust and JBA Consulting	GM	Conditional Licence	• Opportunity • Valuation	Client supplied
Quality Adjusted Life Years (QALY)	NICE https://www.nice.org.uk/advice/lgb10/chapter/judging-the-cost-effectiveness-of-public-health-activities	UK	Open Government Licence	• Valuation	
Cost of Mental Illness	Centre for Mental Health (2010)	UK	Open	• Valuation	
GDP Deflators at Market Prices	ONS (2016)	UK	Open Government Licence	• Valuation	
National Water Environmental Benefit Values (NWEBs)	EA (2013) https://www.gov.uk/government/publications/updating-the-national-water-environment-benefit-survey-values-summary-of-the-peer-review	UK	Open Government Licence	• Valuation	
Council Tax Stock of Properties 2015	Valuation Office Agency (2015) https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2015	England and Wales	Open Government Licence	• Valuation	
Outdoor Recreation Value (ORVal) tool	Day and Smith (2016)	England	Open	• Valuation	

	http://leep.exeter.ac.uk/orval/				
Median House Price by MSOA, England and Wales, quarterly rolling year, 2004-2015	ONS (2017) https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/hpssadataset2medianhousepricebymsoaquarterlyrollingyear	England and Wales	Open Government Licence	• Valuation	Median House Price by MSOA, England and Wales, quarterly rolling year, 2004-2015
JBA Consulting, Irwell Strategic NFM Targeting Maps, May 2017	JBA Consulting www.catchmentbasedapproach.org	Irwell Catchment	Open	• Opportunity	
Multi-Coloured Handbook – Flood and Coastal Erosion Risk Management 2015	https://www.mcm-online.co.uk/handbook/	UK	Conditional Licence	• Valuation	Multi-Coloured Handbook – Flood and Coastal Erosion Risk Management 2015

Licence	URL
Open Government Licence	http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/
Environment Agency Conditional Licence	https://www.gov.uk/government/publications/environment-agency-conditional-licence/environment-agency-conditional-licence
European Union – Full, Free & Open Access	http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159
Ordnance Survey	https://www.ordnancesurvey.co.uk/business-and-government/licensing/using-creating-data-with-os-products/os-opendata.html
Conditional Licence	Licence terms vary by data type and data source. Contact data source for more information.

APPENDIX B: SUMMARY OF STAKEHOLDER WORKSHOPS

Appendix B: Summary of Stakeholder Workshops

This appendix details all responses received during the two stakeholder engagement workshops held on 26th September 2017 and 1st February 2018. All responses within this document are the opinions and views expressed by those in attendance and do not represent the opinions and views of GMCA, TEP or Vivid Economics.

Stakeholder Engagement Workshop 26th September 2017: Group Discussion

Topic 1: Stakeholder input and review of methodology

How do you feel you can input into this project?

Are there any stages of the project that require more explanation?

Mapping

- Mapping needs to take account of deprivation, especially health
- Typology of brownfield sites needs further consideration to ensure accuracy.
- Strava / Fitbit to assess actual use of open spaces in river corridors.
- Make sure we build on Natural Capital Scorecard (EA work)
- Can we consider "landscape"?

Ecosystem Services

- Can "food production" be scoped in, accepting it will not be a high-value benefit?
- Food production could be relevant in regards to release of Green Belt land for development.
- Although Food production does not cover a large proportion of the Irwell Catchment, it is still important that it is not discounted, for example there are a number of Riverside Orchards and Local Producers.

Habitat Mapping

- Need to include within the final report a clear description of an 'Asset'.
- Aerial Photography should be used to refine the habitat mapping.

Waterbodies

- The scope of the project should be expanded to include Canals given the recreational and health benefits they provide to users.

Accessibility

- Need to ensure the study takes account of safety when assessing the quality of spaces. Could the study take account of crime statics (indices of deprivation) to highlight areas where safety improvements are required.

Ground Checking of Mapping

- Although it is acknowledged that this may not be part of the current scope of the project, it is important that ground checking is included to test the mapping of habitats.

Topic 2: Width of river corridor for detailed study.

Do you agree with the 100m buffer from the 1 in 100 year flood risk zone?
Can you think of examples where it would need to deviate from this buffer?
Do you think this buffer would work appropriately for rural and urban areas?

- Need to identify reaches and denaturalisation measures appropriate to each reach, and how these measures might mobilise funds.

- MasterMap has some errors in the greenspace e. For example, sports area versus park, in which the park has statutory protection. Talk to Krista about LA corrected data on green spaces: LAs each has its own corrected mapping.

- The scope of the project should be expanded to include the headlands and expanded tributaries of the Irwell Catchment. Through focussing on the main River valley important ecological sites and benefits maybe being missed.

- Without looking at the full catchment of each river valley, there is potential the study will generate an artificial ESS.

How to maximise relevance of study to Local Authorities and land Managers

Do you have any ideas where the study could be useful to Local Authorities and land managers? Can you see how the project could benefit both current and future projects?

Natural Course Relevance

High-level outcomes needed from Natural Course are:

- Good quality catchment management plans
- A tool to stimulate collaborative working between partners, using shared and accessible information
- Information to challenge "accepted wisdom" that a) river re-naturalisation in urban areas is always too expensive or technically unfeasible and b) the benefit – cost ratio of 9:1 used in EA flood defence appraisal is the ultimate arbiter of decision-making (i.e. if a scheme is marginally out, but delivers sig. natural capital uplift, it should be considered).
- Publication of methodology so it becomes available for other UK urban catchments
- Ensure study is relevant to LPA Local Plans and Policy development.
- Need to remember that this a Natural Course Project and the aims of Natural course should govern the core aims of the study.

Renaturalisation Relevance

- The big levers of power when it comes to funding for re-naturalisation and river corridor projects are A) Price Review process (OfWAT) B) Flood defence funding (Defra rules) and C) agricultural support funds and rules

GMCA Relevance

- Make sure this project very specifically ties to GMCA priorities of "Building a great economy, based on a very good environment, and based on people" NB Mayor's Green Summit in march 2018 will include a topic of Natural Capital and this project is a key bit of work to demonstrate at the summit.
- Will be useful to influence high level decision making.
- Demonstrating the strategic benefits from the projects so they are less focused on benefits from their wards only. People will be want to extract information at a range of levels, some very local. Reporting should be simple.
- How to make it taken seriously by LAs and how it will be used in considering planning applications. How the work will be communicated to the various individuals looking at aspects of the planning application at the time of pre-application.
- Worth making Chief Executives aware of it.
- More joined up, integrated asset maintenance plans across local authorities
- The study should seek to create a link between the catchment priorities and ESS.
- A key test for delivering the opportunities mapped within the study will be getting each of the Greater Manchester authorities to work together.
- The study needs to include a much stronger link to the Urban Pioneer project.

Local Authority Relevance

- Provide the report and data on a per-LPA basis as well as a catchment-wide basis.

Developers Relevance

- The Study will be useful for early discussions with developers to show the benefits from a financial perspective.
- As park and land managers: Treasurer keen to reduce costs and sell assets. How LAs can work with other partners to maximise value.

Planner Relevance

- As planners, working with national planning policy, and its fit within GMSF, what can be designated and how it is designated (as GI) and what policies are attached to it and what weight can be applied to it for asking for S106 etc., planners will want it to be simple and to put weights on it against affordable housing and transport infrastructure.

- Offer a user guide for planners. Ties into wider discussion on net gain. Link with Derek's team, which comments on developer planning applications. If GM were to ask districts to use this information, LAs and subsequently developers might take it up. May need statutory weight as a formal part of the evidence base. Could be part of the planning application checklist.

- Putting catchment thinking – upstream impacts downstream – into planning thinking. Currently planners only look at the location itself. But the considerations could be considered to take into account of relationships within the catchment and other ESS provision.

Replication of Method

- The study should seek to define the methodology so the work can replicated across other catchments.

Project mapping and inventory and screening opportunities.

As you can see from the mapping a lot of the IMC has been heavily modified, what do you think would be the best way of screening for opportunities to achieve the most benefits?

Priority Projects

- *Projects that improve flood risk are political priority*
- *Projects that stimulate active travel for short journeys are a LTP priority. Can river corridors provide this opportunity?*
- *Quality / Safety of open space is a driver of uptake – can we use potential for quality uplift as a screen for opportunity? E.g. signage, paths, entrance points?*
- *For UU, whilst the primary driver is water quality uplift, projects that also increase amenity or other public benefits are welcome as they offer opportunities for UU to join a partnership of funding and delivery.*
- Overlapping data on heat island, health (mental health, asthma) should identify priority areas are for intervention.
- Set criteria for screening opportunities.
- Opportunities should be closest to people (where they works not just live).
- Priority of what is desirable and what could be delivered, given funding streams (such as by EA). Some sites could be embedded in masterplans.
- Some are site specific opportunities while others are more generic. The more generic opportunities.
- What are the quick wins, deliverable within the next three months: for example, small amounts of money.
- A mixture of opportunities of £10s k, £100k s. With various timescales of up to 3 to 5 years.

Current / Previous Projects

- Don't get too dragged into lists of projects that have been generated already (this work is being carried out by others). Maintain a focus on the natural capital assets in each river corridor and combine this with a "heat-map" of needs to generate opportunities (e.g. where there is an unmet need).

Future Projects / Opportunities

- Water companies have large investments but they are limited to their assets.
- A large challenge in the various funding pots. Coordination of funding in relation to other funding.
- How to take into account the preferences and aspirations of local people.
- The study should be used to highlight where potential projects could have the maxim benefit.
- Investment opportunities should be linked heavily to flood management.

Where could the mapping GIS tool help?

Can you think of any examples?
Do you have anything similar that you use at the moment?
How best would you envisage using the data?

Data

- Ensure tool uses Open Source data as far as possible
- National cycle route 6, Rochdale, valley of stone greenway, a strategy investment in Lancashire, funded nationally via LEP.

Tool

- A tool to stimulate collaborative working between partners, using shared and accessible information
- Enable a user to cookie-cut info per Local Authority
- Wildlife trusts and others will wish to use it.
- Any thought given to maintenance and updating of the tool. What might its lifetime be?

Incorporation into Existing Web Mapping Tools

- Noted the use of the Local Action Plan online tool for communities. This tool provides the opportunity to be proactive rather than reactive.
- Mapping GM. To be able to have GMSF layers and outputs from this study together. Provides wide access. Some will want to access via internet, some via GIS applications. StoryMap is also confronting these questions.
- So would need also in MapInfo format. MarioMaps is used by Lancashire County Council, but LAs are not signatories to the data.
- Local Action Project Defra-funded project for part of Irwell catchment (Manchester within the M60), the end user was the community groups. Allowed the community to look at their own environment. Allowing them to see what projects could be done locally. Web-based BOUNTY tool.

Stakeholder Engagement Workshop 1st February 2017

Summary

The session was attended by a high number of attendees and represented a good mix of stakeholders, partners, and public and private organisations. The response during the presentations and to the questionnaires was very insightful and provided an excellent test for the methodologies applied, and analysis completed to date.

Broadly speaking the majority of responses to the work completed to date was positive, with many comments on how the processes presented could be improved or amended to provide a more comprehensive final report and mapping tool.

Several key points were raised in terms of the mapping tool and the ability to integrate the parcel scores and compare to other datasets which will guide decision making. These comments will be taken on board and focus will be given to making the data provided from this study as simple to understand as possible with user guides provided. Where possible datasets to support the study will be provided.

Comments were recorded which detailed issues and concerns over the terminology used in the presentation and methodology. These comments are acknowledged and focus will be given to ensuring the final report will be clear and informative when describing the processes and analysis completed in the study.

Comments relating to the extent and scope of the project were also recorded, highlighting either wider geographic coverage or greater spread of Ecosystem Services. These comments are acknowledged and logical in their assertion. The scope the project in terms of study boundary and services has been agreed with the client and steering group.

In terms of the map outputs from the project, comments received included: colours, displays, extents and score banding. These comments are acknowledged and will be incorporated into the final outputs of the study.

Details are provided in the following pages on specific comments raised on the feedback sheets, with short summary responses also provided.

Question 1. What are your thoughts on the methodologies used? Are there any gaps, best practice studies, strategies and data that we have not included?

Services

- Amenity is more than Trees.
- Not convinced that amenity score is based on a wide enough data set to score equally with other. Basically just trees.
- Biodiversity is an obvious gap in the economic assessment.
- Good but would like to see biodiversity and quality represented.
- It is difficult to produce a model which accurately includes all factors in detail. For example green spaces hold higher recreational value (aesthetics). Also Air Pollution is much more complex in terms of suitable plants which offset impact.
- Arbitrary thresholds might warrant more justification (e.g. Tree Canopy)?
- I would be happier if we knew what we did not know, e.g. a complete analysis would also include these datasets perhaps that had been used elsewhere, and this is the impact on the modelling.
- Have you considered Urban Heat Island data?
- Eco Networks – many rivers are disconnected by culverts / canalised reaches that impact on environmental quality including flood risk, amenity and water quality.
- Good application of best practice – need to emphasise that outputs are for decision support not decision making.
- Good range and scope.
- Good starting point for local and big planning opportunities.
- Good equal costing across the areas and so no “favouritism”.

Strategies

- Other Environmental studies in catchment e.g. Weetwood Surveys of HMWB’s and opp’s in River Irwell Catchment.
- RRC River Irk Restoration Strategy.

Mapping Tool and Datasets

- Be good to make sure datasets are available to Irwell Catchment Partnership.
- GMSF Allocations and sites need to be shown on the final mapping tool.

- Would prefer “string of beads” to include whole sites connected to river rather than buffered area.

- Local authority policy allocation both land proposed for development scoring negatively. Land allocation for recreation scoring positively.

Question 2. Do you think any of the ESS require a higher weighting in the Opportunity Mapping?

- Yes, would like to see higher weighting for water quality and health.
- Opportunity costing would help a balanced assessment.
- Proximity to habitats – do we need to offset the issue of not modelling biodiversity data?
- What scale of buffer zone could be applied to designated sites to enable benefit to wider non-designated?
- Transformative opportunities in strategic regeneration frameworks e.g. Northern Gateway, NMOA, Mayfield and Eastland's.
- Hard to tell at present, need to see individual scores.
- I think it is best to consider this as an incremental step of a model under development. Some calibration with factors which have been weighted differently would be helpful.
- Might help to see list ordered highest weight to lowest.

Question 3. Do you agree with the data outputs being presented at a Catchment Wide, District level and Waterbody level?

- It will be interesting to see individual ESS Mapping to explore exactly why opportunity areas have been assigned allowing targeting of actions.
- If catchment wide – better connectivity with existing greenspace particularly wildlife sites, public parks outside of the riparian corridors.
- Again, each is useful to answer different questions and (although resource dependent), a smaller scale than district might be beneficial for other reasons.
- Hard to interpret without knowing the type of opportunity being addressed.

Question 4. Are there any areas identified on the heat maps that should not be in there and reasons for this?

- Any view of contouring would help with feasibility.
- Maybe land ownership as this could dictate if land has potential maybe? – Could affect weighting of amenity – etc.
- Need to identify where there has been a large industrial legacy i.e. contamination, culverting, canalisation of river has impacted on the overall environmental value of these river corridors.
- Lower Hinds is an alkali waste tip.
- Yes, maybe the project needs to include a "ground truthing" session with each Local Authority to omit or add sites.
- The tabled maps are composite so the reasons for site inclusion / exclusion cannot be interrogated.

Question 5. Alternatively, are there any areas that should be in there that are not currently identified?

- Other connectivity paths (water quality) – e.g. Highways drainage, combined sewers. Opportunities may exist at greater distances from water bodies to improve water quality and enhance other ESS.
- The maps are river corridors and boundaries are drawn tightly. There may be adjacent areas that need to be included.
- Some areas where there is planned future development are not shown.
- Key large scale flood schemes would be useful to show.
- Be useful to see suggested linked layers in tool for ease of use e.g. areas of deprivation.
- Any map of invasive species along water bodies possible?
- Would like to see overlay of “Northern Gateway”.
- Identify major flood risk and NFM capital scheme areas planned by Environment Agency and Partners.
- Strategic development areas in Manchester, Medlock - Mayfield / Gt Jacksons, Irk – Northern Gateway.
- Castle Irwell Flood Basin. Has been made but assuming that you are using historical data, it should be very high potential. I understand that it was caused by a data gap but it does seriously reduce faith in the methods used.
- Field south of Goshen Playing field on Roch, Flood Basin.
- Yes, maybe when the online mapping is available the map for each ESS could be checked with each local authority.

APPENDIX C: HABITAT TYPES DEFINITIONS AND MAPPING PROTOCOLS

Appendix C: Habitat Types Definitions and Mapping Protocols

Introduction

The mapping of habitat types and sub-types within the study area enable the identification of "*natural capital assets*". Each habitat type can deliver or support one or more ecosystem services as well as provide opportunities for natural capital increases. To provide detailed analysis, each of the broad habitat types has been further subdivided into sub habitat types. The full list of broad and sub habitat types is provided in the table below. Approximately 124.4 hectares of the study area is "unclassified". The unclassified status is derived directly from Ordnance Survey (OS) MasterMap, and highlights areas of land use that are unknown. In most cases this is due to development or land use change occurring. OS update MasterMap on a rolling 6 weekly programme, therefore the number will expand and contract as development commences and completes, although rerunning the habitat mapping analysis every 6 weeks to account for this may not be feasible. To maintain the integrity and repeatability of the study the unclassified areas have not been manually amended, but this exercise could be completed in the future. Where additional datasets do not indicate the habitat type within a predetermined confidence level, the OS MasterMap parcels remain as unclassified.

A notable example of unclassified OS MasterMap parcels within the Irwell Management Catchment (IMC) include the recently completed £10m Salford Flood Improvement Scheme[1].

Broad Habitat Type	Area (ha)	Sub Habitat Type	Area (ha)
Agricultural	**5,126.6**	-	-
Greenspace	**4,142.3**	*Amenity*	*1446.7*
		Private Garden	*608*
		Unknown	*605.7*
		Transport	*535*
		Sports Facilities	*481.4*
		Park	*299.4*
		Institutional / Educational Grounds	*86.8*
		Religious Grounds	*58.1*
		Allotments	*21.2*
Urban	**2,932.5**	*Hardstanding*	*815.8*

[1] https://www.gov.uk/government/news/environment-agency-completes-10-million-flood-storage-basin-on-world-wetlands-day

Broad Habitat Type	Area (ha)	Sub Habitat Type	Area (ha)
		Road	*685.1*
		Roadside / Footpaths	*408.1*
		Residential	*282.7*
		Buildings	*260.4*
		Industrial / Commercial	*224.7*
		Unknown	*168.2*
		Railway	*87.4*
Woodland	**2,508.1**	*Non-coniferous*	*2,265.2*
		Non-coniferous Ancient	*133.8*
		Coniferous	*109.1*
Water	**1,024.7**	*River*	*902.2*
		Pond / Lake / Reservoir	*57.2*
		Canal	*31.8*
		Unknown	*20.4*
		Marsh or Saltmarsh	*13*
Semi-natural Grassland	**817.5**	-	-
Unclassified	**124.4**	-	-
Total Area	**16,676.1**		

Data Structure

The underlying base data for the project has been the OS MasterMap product provided for the project using a Public Sector Mapping Agreement with Greater Manchester Combined Authority (GMCA). Utilisation of the OS MasterMap product provides a solid base for consistency in approach across the study boundary, as well as providing the ability for the method to be repeated across other catchments.

The classification of the broad and sub habitat types used the following GIS data layers:

- OS MasterMap;
- OS MasterMap Greenspace;
- OS Open Greenspace ;
- Environmental Designations; and
- National Forest Inventory (NFI).

Using spatial GIS analysis techniques and hierarchy classifications, habit and sub habitat types are provided for each OS MasterMap land parcel providing the solid data base for valuations and opportunity mapping.

APPENDIX D: ECOSYSTEM SERVICES VALUATIONS AND NATURAL CAPITAL METHODOLOGY

Appendix D: Ecosystem Services Valuations and Natural Capital Methodology

Introduction

This appendix sets out the methodologies for estimating the various benefits generated by natural capital in the Irwell Management Catchment (IMC). A section for each benefit category contains a brief literature review and steps for calculations. Table 1 summarises the calculations and sources of data.

Table 1: Equations for Valuation of Natural Capital in the IMC

ESS	Calculation	Source
Mental health	Mental health cost savings: density of green space (%) * population (persons) * improvement in mental health outcomes due to green space density per person (%)* expenditure on mental health in Manchester (£/person)	White at al. (2013) Centre for Mental Health (2010)
Physical health	Physical health cost savings: visits per year to green space per MSOA annual costs per inactive person (£/person) * proportion of active visits * QALYs per active visit * value of each QALY (£)	ORVal tool White et al. (2017)
Amenity	Increase in property value: density of green space in ward (%) * number of dwellings (dwellings) * property price uplift (%)* house price (£/dwelling)	Brander and Koetse (2011)
Carbon sequestration	Value of carbon sequestered by trees: area of woodland (ha) * carbon sequestered per hectare of woodland (tCO_2/ha) * cost of carbon (£/tCO_2)	Forestry Commission (2012) BIS (2017)
Recreation	Estimated number of visitors valued by costs of travel according to varying socioeconomic and green space characteristics (£)	Outdoor Recreation Valuation Tool (ORVal). Day and Smith (2016)
Water quality	Value of improving water quality status: annual per km value of marginal	NWEB Irwell values, 2016 prices

ESS	Calculation	Source
	improvement in water quality (£) (e.g. from current status recorded to improved status) * length of river stretch (km).	
Water resources	Volume of water abstracted by use type (m^3) * unit cost of water by use type (£/m^3)	Environment Agency National Ecosystem Assessment
Flood risk	Cost of flood risk damages: proportion of flood risk area (high, medium, low) in MSOA * probability of flood risk occurring per annum depending on categorisation of flood risk area as high, medium or low * no. of properties in MSOA * weighted annual average damages (£).	MCM handbook (2017) Environment Agency
Agriculture (food production)	Area of agricultural land (hectares)*farm business income (£/hectare)	Rural Payments Agency, Farm Management Handbook 2016/17
Timber production	Annual average timber availability 2017-2021 (m^3) * timber price (£/m^3)	Forestry Commission data derived from UK National Forest Inventory

Mental Health

For this project, the results from the White et al. (2013) study are applied to estimate the impact that publicly accessible green spaces have on mental health. This study assessed whether individuals in areas with different amounts of urban green space (defined as percentage of land covered in green space) have better mental health outcomes (controlling for individual fixed effects and other covariates). Data is taken from the British Households Panel Survey (BHPS) from 1991-2008. The study compares within-person differences in wellbeing associated with living in urban areas containing different amounts of green space using BHPS. The BHPS found that a one standard deviation increase in green space (equivalent to moving to an area with 48 per cent green space to an area with 81per cent green space) leads to a reduction in 0.14 in GHQ and a 0.07 increase in life satisfaction (GHQ is measured on a scale of 0 to 12).

The steps in estimating this relationship are the following:

Step 1: Use dose-response relationship from White et al. (2013) between abundance of green space within a particular area and mental health outcome. This relates to the density of greenspace in each Middle Super Output Area (MSOA), which assumes that the concentration of green space in near proximity to a given population is a good measure of access to green space.

Step 2: Repeat the above calculation for each administrative area. In the study, MSOAs are used as the unit of analysis. Subsequently, the percentage of green space within each MSOA is assumed to be the relevant measure of access to green space.

Step 3: Attach an economic value to reductions in mental health burden. This is monetised based on the benefits of avoided incidence of mental health due to green space in each administrative area.A search for publicly available mental health expenditure in Greater Manchester was not successful. Thus, mental health expenditure data is taken from estimates by the Centre for Mental Health (2010) who derive total economic costs for England. These total costs are estimated for Manchester by calculating per person costs of mental illness in Manchester and aggregating these up according to local population.

Physical Health

The method used in this study is derived from White et al. (2016) which examines the contribution of physical activity in green spaces to improvements in physical health. The method is based on estimating the number of visits that are made to publicly accessible green spaces. An assumption is then made that a number of these visits is 'active', which means that they have positive benefits for physical health and subsequently reduce the economic costs of disease associated with physical inactivity.

The steps in estimating this relationship are the following:

Step 1: Estimate visits to green space in each MSOA (area) using the Outdoor Recreation Valuation (ORVal) tool..

Step 2: Estimate the contribution of green space to physical activity in terms of contributing to active lifestyles (estimated visits*proportion of visits which are active). It is assumed that 50 per cent of visiting to these areas are active.

Step 3: Estimate of QALYs associated with active visits, multiply active visits by 0.010677 to get an estimate of QALYs associated with those active visits (taken from White paper who uses Beale 2007).

Step 4: Calculate monetary value of additional QALYs using the value of £20,000 per QALY (based on NICE implicit value for a health intervention being cost effective).

Amenity Value

The enjoyment that people derive from living close to green spaces is estimated by the price people are willing to pay to live near these spaces. Property prices are commonly used to estimate the economic value of green space. This approach assumes that property prices are a function of various observable characteristics such as property type, socioeconomic

variables and locational factors, such as access to amenities. Using variation of property prices across these different characteristics, it is then possible to estimate the willingness to pay for each characteristic, including green space.

Estimate property price uplift based on proximity to green spaces as in Brander and Koetse (2011). A figure of 5% uplift for properties within 300m was used.

The steps in estimating this relationship are the following:

Step 1: Estimate the number of dwellings experiencing uplift by using dwelling density in MSOA and proportion of green space buffer (ha) by MSOA.

Step 2: Calculate the total uplift (£) by MSOA by applying an assumed uplift of 5% to aggregate house prices (£/dwelling*no of dwellings in Step 1).

Step 3: Calculate % value of uplift by dividing value of total uplift in each MSOA from step 2 by total value of property (£/dwelling*no of dwellings in MSOA).

Carbon Sequestration

The value of annual carbon sequestration by wooded areas in river corridors is calculated according to assumptions about the rate of carbon sequestration in different types of woodland and the avoided costs of emitting carbon dioxide into the atmosphere.

The steps in estimating this relationship are the following:

Step 1: Calculate area of wooded green spaces (ha) by an assumption of the amount of carbon sequestered per hectare of woodland (tCO2/ha), incorporating data from Forestry Commission on woodland type (broadleaf or conifer).

Step 2: Calculate value of carbon sequestration by multiplying cost of carbon (£/tCO2) with amount of carbon sequestrated from Step 1. Cost of untraded carbon dioxide (£63/tCO2e) figure is taken from figures published by Department for Business, Energy and Industrial Strategy (2017).

Leisure and Recreation

To estimate the value of recreation provided green spaces in the IMC, the Outdoor Recreation Value (ORVal) tool devised by Day & Smith (2016) is used. To address uncertainties and lack of data concerning the value placed on recreation values in the UK, the ORVal tool uses an econometric model of recreational demand. Using this model, the ORVal tool is able to estimate values of recreational activities based on the costs borne by respondents in travelling to each type of green space. The purpose of each visit is not included in the model, so visits could feasibly include a range of recreation types, such as short duration visits to enjoy scenery to physically demanding forms physical exercise like hiking or cycling. The model is supported by data from the Monitor of Engagement in the Natural Environment (MENE) survey, which asks people about the amount of time spent in different types of green space and the activities they conduct in these areas. These are restricted to day trips and only for adults residing in England.

The steps in estimating this relationship are the following:

Step 1: Estimate the number of recreational visits associated with recreational visits using the ORVal tool for each MSOA overlapping with the Irwell river corridors .

Step 2: Report the associated economic value (£) of the total number of recreational visits using ORVal.

Water Quality

The economic value of water quality is calculated using the Environment Agency's National Water Environment Benefit (NWEB)[1] values. The NWEBs provide economic values for recreation, amenity and non-use benefits of improving the quality of the water environment in terms of £/km. These values are linked to different Water Framework Directive (WFD) measures of quality status: from bad to poor, poor to moderate and moderate to good. The EA's NWEB values include catchment specific values. For this study the values for Irwell catchment are applied. We use these values to provide an indication of the potential indicative benefits to be achieved in terms of recreation, amenity and non-use value from improving the quality of the river corridor stretch (with conservative assumption of a one-step improvement in status).

The NWEB values for the Irwell catchment are shown in the table below (2012 prices). For the purposes of the analysis, we use the central values, uprated to 2016 prices.

National Water Environment Benefit (NWEB) values for Irwell Catchment

£/km improved (Central, £ '000, 2012 prices)	Bad to poor	Poor to moderate	Moderate to good
Irwell catchment	25.5	29.8	35.1

Source: Environment Agency

These values are applied to each river corridor stretch in the Irwell catchment by estimating the potential benefits achievable from a one-step improvement in WFD status (i.e. if the status is reported at moderate, then the estimated values would be to move to good from moderate). Note, this analysis only reported potential benefits; in practice, it may not be always possible or cost-beneficial to achieve these improvements. The calculations also do not provide a baseline value for the water purification services provided by the natural assets in the river corridors of the Irwell catchment.

Flood Risk

The focus of this study is to provide a baseline assessment across river corridors of flood risk damages linked to residential property. The valuation approach is informed by guidance from the MCM handbook2 and follows their high-level approach to appraisal of flood damages

[1] https://www.gov.uk/government/publications/updating-the-national-water-environment-benefit-survey-values-summary-of-the-peer-review

[2] Flood and Coastal Erosion Risk Management: a manual for economic appraisal: https://www.mcm-online.co.uk/manual/

suitable for providing an initial approximation of flood risk damages using the weighted annual average damages (WAADs) figures provided. This can help to provide an indication across the river corridors in the catchment of the indicative benefits to be potentially achieved if natural flood measures were targeted in those locations.

The steps in estimating this relationship are the following:

Step 1: Estimate the number of properties in high, medium, low risk flood area of each MSOA by multiplying proportion of flood risk area (area at low, medium, high risk / MSOA area) * no. of properties by MSOA.

Step 2: Estimate expected no. properties damaged by flood in each flood risk area by using the probability of flood risk occurring per annum in each flood risk area (high, medium or low) and the corresponding no. of properties of this area estimated in Step 1.

Step 3: Calculate weighted annual average damages from flood risk in each flood risk area by multiplying no of properties.

Step 4: Estimate expected damages of each MSOA by aggregating flood risk damages from high, medium, low flood risk areas at the MSOA level.

MSOA area is disaggregated to find areas which are at high, medium, and low levels of flood risk. The proportion of each flood risk area is calculated as area of flood risk relative to the whole MSOA area. This results in % of area at low risk, medium risk, and high risk (see definition of low, medium, high flood risk in notes section below).

Weighted annual average damages (WAAD) per property (no flood warning and no flood protection) is £4, 728 (2013 prices) uprated to [2016] prices.

To calculate total expected flood risk damage at the MSOA level, flood risk from low, medium and high areas within each MSOA are aggregated.

It is assumed that properties are evenly distributed throughout an MSOA. This may be an unrealistic assumption as high flood risk areas may have fewer properties situated on them.

An additional assumption is that flood risk is calculated according to midpoint probabilities of each area:

- Low: 1 in 100 to 1 in 1000 (mid-point 0.005%)
- Medium: 1 in 30 to 1 in 100 (mid-point 2.2%)
- High: > 1 in 30 year (3.3% probability)

The remaining category of flood risk is very low which is < 1 in 1,000 so this not accounted for in the analysis of expected damages as the expected damages would be close to zero.

Agriculture (Food Production)

Agricultural provisioning services refer to economic value of products derived from farmland. In the UK, this could entail arable and pastoral agriculture, or more specialist farming types, such as horticulture. These agricultural products can then be sold, earning income for farmers. To reflect the welfare that farmers receive from producing agricultural products, a measure of net income is used, which deducts the costs of production from the revenue gained from selling crops.

The steps in estimating this relationship are the following:

Step 1: Calculate the number of hectares of agricultural land within 100m of each waterbody in the catchment using Rural Payments Agency data. Land parcels that are shown under the Single Payment Scheme are deemed as agricultural.

Step 2: The type of agricultural activity on each parcel is assumed based on local advice about the forms of agriculture conducted in the catchment. Calculation revealed that the majority of land was grazing land used to rear livestock. It is assumed that half of the land areas is devoted to Less Favoured Area grazing livestock farms and the other half as lowland grazing livestock farms. These farm types are defined in the Farm Management Handbook 2016/17.

Step 3: Per hectare farm business income for each farm type in England is given in the Farm Management Handbook. Farm business income refers to gross margin minus the fixed costs of production. For Less Favoured Area farms, this is £98 per year. For lowland grazing farms, this is £118 per year. These two figures are averaged to estimate the representative income from one hectare of grazing land in the IMC.

Timber Production

The value of standing forest and woodland is a potential source of income for public and private sector owners. This report calculates the annual value of timber that is currently harvested around the river corridors in the study area.

Estimating the amount of timber production is subject to a number of caveats for two main reasons. First, the standing volume of timber and its associated value is dependent on the species and types of woodland present. Observed species data, however, is not available. In lieu of this, tree species are estimated by the Forestry Commission in its National Forest Inventory. This estimates the distribution of species based on point samples of forests and woodlands taken across the UK. The sampling methodology means that at small geographical scales, estimated species distributions will be subject to higher standard errors. Second, the exact location of forest management activities is not known due to the range of different managers of forests and woodlands in the UK. Thus, the estimated volume of timber harvested will depend on observations of management activities, such as clearfelling and thinning, across sampled sites near the catchment. As with standing volume estimation, this may be liable to error.

The steps in estimating this relationship are the following:

Step 1: A 50 year timber forecast was provided by the Forestry Commission for the IMC as a whole. One-third of woodland lies within the river corridor study areas, so it is assumed that timber availability in river corridors is one-third that calculated for the whole catchment. Average annual volume for the period of 2017-2021 is used for this study's calculations. The timber availability volume is given in m^3 separately for softwood and hardwood.

Step 2: Annual timber revenue is estimated by multiplying softwood and hardwood volumes by their respective prices. Price data is taken from Forestry Commission Price Indices. It is assumed that annual revenue is equal to the resource rent owing to the low marginal costs of maintaining woodlands after tree planting.

Water Resources

The direct use of water in the Irwell is calculated using the locations of water abstraction. The economic value that the availability of water has in these locations is calculated based on the costs that would be incurred from transporting water from another location for the same use.

The steps in estimating this relationship are the following:

Step 1: Collate data on the annual volume of water abstracted from surface water and ground water resources in the IMC provided by the Environment Agency. This provides a breakdown of abstractions for different uses: agriculture, water supply, industrial, commercial and public services, production of energy, amenity, and environmental. Environmental includes use in relation to river/wetland support, transfer between sources and pollution remediation. Amenity use includes water used for parks, golf courses, swimming pools, etc.

Step 2: Apply unit values for water abstraction to quantify the monetary flows of water abstractions. The range for unit values are based on a combination of resource rents and values for use in different sectors. The resource rent for water is the value after all human inputs have been subtracted, in practice gross operating surplus minus user costs of produced assets. A Defra report published in 2015 calculated unit resource rents, £/m^3, to apply to public water supply abstraction in England & Wales. This is supplemented by abstraction values by different uses from UK National Ecosystem Assessment (2011) updated to 2017 prices. Environment NEA values are based on WTP value of freshwater left in situ in the natural environment.

APPENDIX E: OPPORTUNITY ASSESSMENT – METHODS AND MAPPING PROTOCOLS

Appendix E: Opportunity Assessment – Methods and Mapping Protocols

Methodology

This appendix details the methodology used to assess Ecosystem Service (ESS) opportunity mapping for the Irwell Management Catchment (IMC). The tables on page 8 onwards indicate the rationale, data sources and scoring thresholds used for each ESS.

The method has been developed by GIS and Spatial Analytical specialists using best practice techniques, stakeholder engagement and environmental specialists. It builds on the methods adopted in precedent studies including;

- West Country Rivers Trust, Participatory ESS Services Visualisation Framework. https://issuu.com/westcountryriverstrust/docs/wrt_ess_visualisation_manual_v1-1-s
- Local Action Toolkit, Mapping Methodology (2016). Report for Defra (Project Nr. WT1580) http://urbanwater-eco.services/project/local-action-toolkit/
- DEFRA BOUNTY Tool (2016/17) https://demos.the-iea.org/WS20161130/
- University of Northampton (undated), Mapping Natural Capital and Eco System Services in the Nene Valley. http://docplayer.net/33332104-Biodiversity-and-ecosystem-services-in-the-nene-valley.html
- West of English Nature Partnership (2016) "Eco System Services, Understanding Nature's Value in the West of England" http://www.wenp.org.uk/ecosystems/
- City of Trees (2017) Green Infrastructure for Water, Mapping for the Irwell and Upper & Lower Mersey Catchments http://www.cityoftrees.org.uk/project/green-infrastructure-water

Where possible, and to assist with future replication in other urban areas, national open source datasets have been used, with specialist, local datasets used to refine the processing.

For the purpose of this assessment, an "opportunity" is a geographic location or a specific parcel of land which, given its physical, social, economic, geographic and cultural characteristics, offers the possibility of interventions to be implemented to improve ESS functioning and thus uplift natural capital.

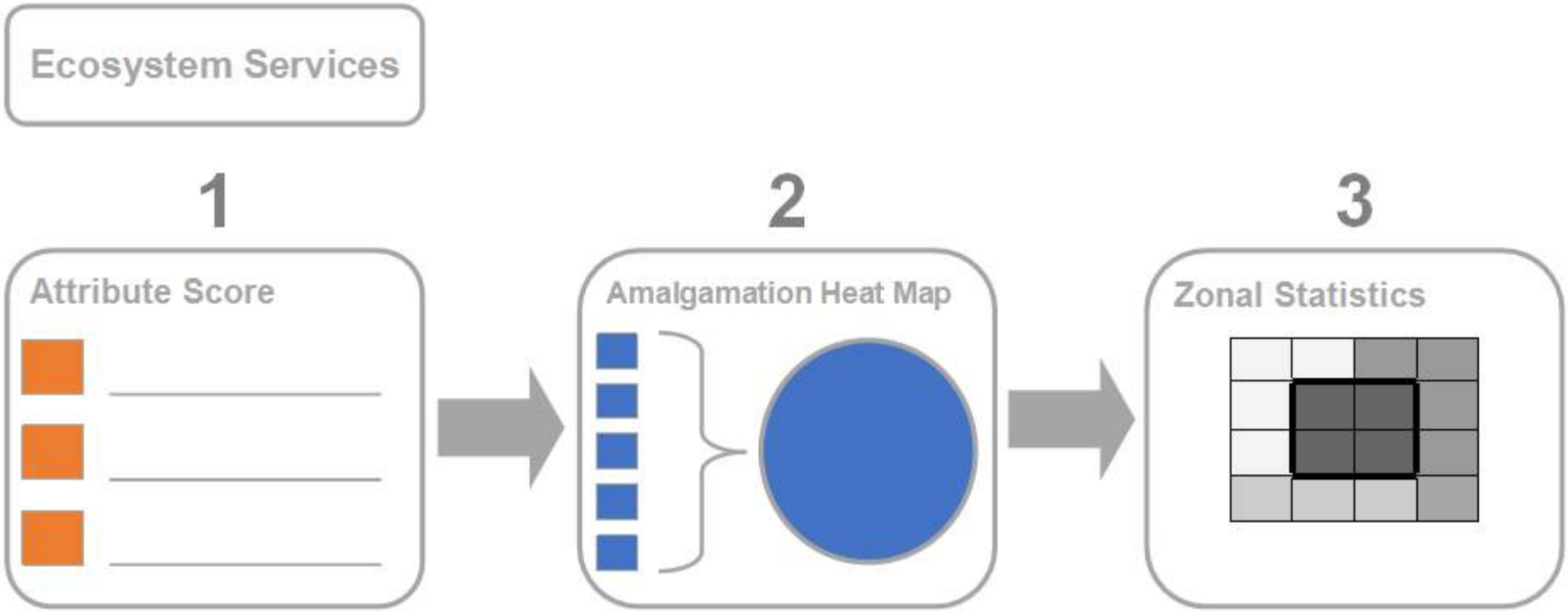
The opportunity maps are grouped by ESS. For each ESS, there may be several types of interventions. For example, to improve water quality, one could intervene to plant trees or establish reedbeds to filter sediment or polluted surface water on its flow to the river, one could remove artificial barriers to fish migration, and one could manage agricultural land to reduce sedimentation. For leisure and recreational ESS, typical interventions are improving accessibility of open land, improving cleanliness.

The assessment and analysis of opportunities for each service are calculated in three key stages and demonstrated by the diagram below.

The first stage is the analysis of a series of opportunity attributes which singularly and collectively effect the service in scope.

The second stage is the amalgamation of all the opportunity attributes for each service into a heat map, which identifies the areas of greatest opportunity.

The third stage in the process is the bringing together of opportunity heat maps across all services to create statistics which can be assessed on a catchment wide or individual waterbody perspective.



Opportunities are mapped for each land parcel in the study area. There is no mappable opportunity where:

- There is no need for ESS uplift – for example there is no need to improve leisure and recreational ESS where there is no community within walking distance of the site (walking distances being defined using Access to Natural Greenspace (ANGSt) thresholds);
- The land parcel is already in favourable condition – for example in relation to carbon sequestration ESS, woodland is the most favourable condition;
- The land parcel does not lend itself to the intervention in question – for example, one would not normally create Sustainable Drainage Systems (SUDS) in a cemetery or a designated ecological site or a priority habitat;
- The intervention will not feasibly result in ESS improvements. For example, land that is not hydrologically connected to the river will not deliver water quality ESS benefits to the river in question.

Where there is no opportunity, the relevant habitat type or land parcel is either "excluded" from the analysis or scored at zero. The exclusions listed in the detailed method statements below relate to the habitat classifications described in the Technical Appendix on habitat types.

Where there is opportunity, the land parcel is scored. Scores may be awarded based on attributes such as location, proximity, land-use, habitat type, designation, or recreational function.

Scores may be binary (1 = opportunity, 0 = no opportunity) or may be scaled in relation to the level of need or the "depth" of the opportunity (for example, land that is almost devoid of tree cover, but could be planted, may score 2, whereas land that is deficient but not devoid of tree cover may score 1). For most ESS, there are several scoring attributes and criteria.

Based on the overall score per ESS, raster "heat maps" are generated showing the opportunity scores assigned to all land parcels in the study area. Each opportunity output was rasterised using the score as the grid value.

Once complete each scored raster was added together using GDAL. Once opportunity heat maps are produced for each ESS, a composite heat map is generated showing all ESS opportunities grouped. Zonal statistics is used to identify which reaches provide above-average opportunity scores for each ESS.

Scope of Services

Opportunity Mapping and ESS Valuation methodologies have been developed and completed for the following ESS:

- **Water quality** *(including soil analysis)*
- **Water resources** *(valuation only)*
- **Flood risk mitigation** *(including soil analysis)*
- **Amenity** *(including health analysis)*
- **Carbon sequestration** *(including soil analysis)*
- **Leisure and recreation** *(including health analysis)*
- **Biodiversity and ecological networks**
- **Agriculture (food production)** *(valuation only)*
- **Timber production** *(valuation only)*
- **Air quality** *(opportunity mapping only)*

At the time of report creation we are currently not including the following ESS:

- **Noise Reduction**

  Recent estimates of the impact that areas of trees (greater than 200 m²) have on reducing noise pollution are available for Greater Manchester: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=19843

  The analysis within this is undertaken by estimating how much noise is mitigated using spatial noise maps and house location data to identify beneficiaries. It was found that 429,000 houses benefit from noise reduction in Greater Manchester and this is valued at £59 million per year.

  We have discussed with Defra the possibility of utilising UK Urban Natural Capital Scoping outputs in this project. For the current project, we suggest that valuation of noise pollution should not be carried out by Vivid/TEP since:

  a. estimates for Greater Manchester (which does not cover the whole of the project area) already exist and may be made publicly available at later stages of the project;
  b. Defra are working on noise pollution benefit calculations for the whole of the UK. They indicate this work will become available during this year; and

c. credible modelling of noise pollution benefits would require additional resources, both from Defra/CEH and Vivid/TEP.

- **Temperature regulation**

  Most models of the cooling effect of vegetation are employed at the local level for urban areas. A downside of these models are that they are computationally intensive and require detailed knowledge about the relationship between different vegetation types and the surrounding atmosphere. Examples of urban cooling effects are currently being estimated at the city-level for London and for the UK. Hence, the spatial resolution is extremely large and does not factor in local differences in air temperature.

  Additional option considered was the STAR (Surface Temperature and Runoff) tool. This can be used at a neighbourhood scale – 5km2 (in the North West of England and beyond) to test the impact of different land cover scenarios under different temperature and precipitation scenarios. A weakness of the tool is that predicted temperature is an average value for each study area. It is suggested that a city or local authority level would be too large, whilst a street or a couple of buildings may be too small. Application of this tool to this project is thus limited by uncertainty about optimal study area size, non-replicability of tool over of multiple locations and uncertainty over correct land cover scenarios. In light of this, we do not think that it would be feasible to carry out a valuation of this ESS within the IMC.

- **Pollination**

  The economic valuation provided by pollination is not estimated in this project. Previous attempts at valuing the market benefits of pollination in the UK have focused on the contribution that make to growing a range of crops. The contribution pollinators play varies according to the dependence ratio, which captures the proportion of crop value attributed to pollinators. This ratio is high for fruits (~60%) and moderate for oil seed rape (~25%). Given that the value of agricultural production is already considered in the project, the value of pollination would depend on the types of crops grown in the IMC. Owing to the majority of agriculture in the area is grazing land, the contribution of pollination to production is likely to be very small. As is summarised by Hanley et al. (2013), “There is no robust evidence base on the marginal value of marketed output lost or gained due to changes in pollinator populations for a range of relevant crops. We also have no clue about the non-market economic benefits of increases in pollinator populations.”

Data Limitations

Through the development of the habitat mapping, ESS valuations and opportunity mapping limitations to the data available have been observed. The list below provides information relating to any data limitations:

- **2m LIDAR Digital Terrain Model:**
  There are areas within the IMC and study areas that are missing LIDAR coverage. This limitation is difficult to work around without reducing the accuracy of analysis in areas that have LIDAR coverage. The Environment Agency recently committed to having full UK coverage by 2020[1].

- **OS MasterMap Greenspace / OS Open Greenspace:**
  The OS Greenspace line of products are designed only to cover urban areas[2]. The IMC extends beyond these defined urban areas. Outside of these urban areas identifying Greenspace becomes extremely difficult and time inefficient given the manual classification task.

- **OS MasterMap:**
  There exists parcels of MasterMap that do not have classifications. Assigning these parcels with ESS habitat types poses a challenge where no additional data exists. Throughout the IMC, there are 309 hectares of unclassified parcels. This represents 1.04% of the total classified ESS habitat types within the IMC.

- **Agricultural Land:**
  Data from the Rural Payments Agency has identified all parcels of land within the IMC that have an associated claim under the Basic Payment Scheme (former. Single Payment Scheme). This has identified approximately 9,500 hectares of land that is agricultural in nature. Previously, without this data, it was estimated that there was approximately 7,500 hectares of agricultural land. An under estimation of 26%.

- **Soils Data:**
  Analysis based on soils data has been compiled using the freely available European Soil Database v2.0. Higher resolution data is available at an approximate cost of £4,000.
  Accurate analysis of soils will require detailed local assessment of the soil type and condition in a particular location.

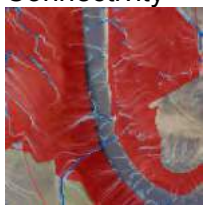
[1] https://environmentagency.blog.gov.uk/2017/12/30/uncovering-englands-landscape-by-2020/
[2] https://www.ordnancesurvey.co.uk/docs/product-guides/osmm-greenspace-product-guide.pdf

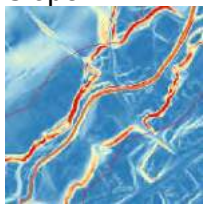
- **GM Cycle Routes/ Sustrans:**
  Some discrepancies exist between the data provided by Sustrans and the data made available by Transport for Greater Manchester (TfGM).
  Namely routes that appear in the city centre are not present in the data provided by Sustrans.

- **Greater Manchester Tree Audit (City of Trees)**
  The Greater Manchester Tree Audit completed by City of Trees provides approximate tree locations and crown spread. The data is limited to Greater Manchester and does not cover the Lancashire areas of the study boundary.

Water Quality

The following attributes are assessed; land connectivity, hydrological connectivity, slope, land use and consented discharge locations. This method closely follows the West Country Rivers Trust approach, adapting as necessary to the urban context of this study, and bearing in mind the less fine-grained resolution of open source soils and agricultural data available for the IMC. On the other hand, we have been able to achieve a finer grain of analysis in respect of hydrological connectivity. The maximum possible ESS opportunity score for water quality is 8.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Land Connectivity 	One of the greatest impacts on water quality is from pollution or sediment arising from, or passing over land immediately adjacent to the water course. Interventions can be implemented to filter or remove pollutants and thus improve water quality.	Typologised habitat parcels are selected where they fall within 20m of a Heavily Modified Waterbody (HMWB). Limited LIDAR coverage.	• OS MasterMap.	0	Where a parcel is not within 20m of HMWB	• Private gardens; • Unclassified; • Urban; and • Water.
				1	Where a parcel falls within 20m of HMWB.	
Hydrological Connectivity 	The method identifies the location and type of land with clear hydrological connectivity to water courses. This model determines the location of land and number of cells that drain into neighbouring cells, building flow lines. This	Using SAGA-GIS 6.1, a Flow Accumulation (Flow Trace) model is computed using 2m Digital Terrain Model (DTM) LIDAR on Greenspace, Agricultural, Woodland and Semi Natural Grassland habitat parcels. Limited LIDAR coverage.	• EA 2m Digital Terrain Model LIDAR.	0	Where parcels are not hydrologically connected.	• Unclassified; • Urban; and • Water.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
	represents where, based on the topography, flow will accumulate and/or drain. Interventions such as new reedbeds, woodlands or washlands in the flowpaths can help filter or bio-accumulate pollutants prior to them reaching the watercourse			1	Where parcels are hydrologically connected.	
Slope 	The gradient of land adjacent to water courses can greatly affect water quality through surface run off and erosion. Surface run off can effect water quality through pollutants travelling into the water course. Highest risk parcels are generally considered to be those with mean slope over 7°, but parcels with any slope can generate run-off under some conditions. Interventions could include tree-planting or “rough-grass”	With 2m DTM LIDAR a slope map is generated using GDAL. Using the generated slope map, zonal statistics are computed using Greenspace, Agricultural, Woodland, and Semi Natural Grassland habitat parcels. The result is rasterised based on the mean slope per parcel. Limited LIDAR coverage.	• OS MasterMap; and • EA 2m Digital Terrain Model LIDAR.	0	Mean Slope < 5°	• Private gardens; • Unclassified; • Urban; and • Water.
				1	Mean Slope ≥ 5° < 7°	

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
	buffer strips to stabilise soils or filter overland flows.			2	Mean Slope ≥ 7°	
Soil Characteristics 	The condition, character and type of soil can greatly affect water quality. Soil type and its characteristics can affect the levels and extents of surface run off. Interventions to improve soil depth and stability would reduce leaching or run off affecting watercourses.	Due to the low spatial resolution of the available soil data, and the urban environment in and around the waterbody, it is assessed that the "urban" soil types for all the study area represent the highest relative risk of run off generation and leaching. Therefore highest score is assigned to each Agricultural, Greenspace, and Woodland habitat parcels for both scoring categories.	• European Soil Database v2.0; and • OS MasterMap.	1	Increased risk to water quality through run off generation.	• Unclassified; • Urban – Buildings, Rail, Roads; and • Water.
				1	Increased risk to water quality through leaching.	
Land Use 	The use of land adjacent or near to water courses can affect water quality. Broadly urbanised environments near to waterbodies have a greater negative effect on water quality through primarily run off and land activities. Woodland is considered to be the land use which is lowest risk in terms of	Habitat parcels scored on the opportunity based on their posed risk to water quality, and the broad "number of steps" to woodland along the spectrum "Arable/Urban" to "Permanent Grass" to "Woodland".	• OS MasterMap.	0	Woodland	• Unclassified; • Urban – Buildings, Rail, Roads; and • Water.
				1	Greenspace	
				2	Agricultural land	

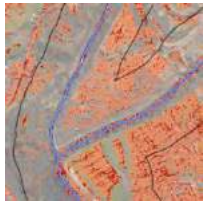
Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
	contaminant drift, adverse uses or soil erosion.			2	Urban	
Consented Discharge Locations 	Locations of direct discharge points into water courses have an impact on water quality. Interventions may be possible at the point of discharge to create filters or buffers	OS MasterMap parcels comprising agricultural land and greenspace that spatially intersect with a discharge point are identified.	• EA Consented Discharges; and • OS MasterMap.	0	Parcel doesn't contain Discharge Point.	• Unclassified; • Urban; • Water; and • Woodland.
				1	Parcel contains Discharge Point.	

Flood Risk Mitigation

The following attributes are assessed; size of upstream catchment, number of properties at risk of flooding, existing or proposed red, amber, green flood risk schemes, flood plain connectivity and land potentially used for re-wetting/ wetland creation. This method closely follows the West Country Rivers Trust approach, adapting as necessary to the urban context of this study. The method also draws from ideas piloted in the City of Trees 2015 to 2017 study on Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments, including the concept (developed by TEP for this method statement) of identifying flow paths.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Habitat Exclusions
Size of Upstream Catchment 	Natural Flood Management techniques have been evidenced by the Environment Agency to provide local flood risk management benefits. This includes reducing peak flows and downstream flood risk through targeted use of the floodplain to store water. The benefits of these approaches are greatest in small sub-catchments.	Higher prioritisation has been given to properties with a small upstream catchment above them and where they are within Flood Zone 3. EA waterbody sub-catchments are scored based on their area.	• EA Waterbody Catchments.	0	≥ 10km2	• Unclassified • Urban – Buildings, Rail, Roads; and • Water.
				1	< 10km2	
				2	< 5km2	

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Habitat Exclusions
Runoff Attenuation Features (RAF)	RAF tend to reduce peak runoff if they are designed carefully to fill at high flows, and drain between events.	Using provided JBA Runoff Attenuation Features in combination with Surface Water Flow paths, parcels are identified that contain both features.	• JBA – RAF; and • EA 2m Digital Terrain Model LIDAR.	0	Parcels which do not contain both features.	• Private Gardens; • Unclassified; • Urban; • Water; and • Woodland.
				1	Parcels which do contain both features.	
Roughening Up the Landscape	Scrubland creation has less impact on the volume of the runoff peak, but can significantly delay the timing of the peak runoff in headwater catchments. Further downstream it can both delay and reduce runoff peak.	This involves the identification of potential land parcels that would be suitable for scrubland creation as an additional enhanced roughness,	• JBA – WfW Scrub Planting; and • OS MasterMap.	0	Parcels which do not intersect with potential scrubland creation areas.	• Private Gardens; • Unclassified; • Urban; • Water; and • Woodland.
				1	Parcels which intersect with potential scrubland creation areas.	

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Habitat Exclusions
Land Potentially Used for Re-Wetting/ Wetland Creation 	This category identifies opportunities for creating or restoring wetlands where land can hold more water and reduce flood risk. The greatest opportunities are associated with land that has a high tendency to be seasonally/ permanently wet. The analysis identified areas of land adjacent of water courses with currently limited or low flow paths, to highlight land with the potential for wetland creation.	Using SAGA-GIS a Topographic Wetness Index is generated with EA 2m DTM LIDAR. The generated raster data values are Normalised. Areas with high "Wetness" are extracted, vectorised, and areas < 16m2 are removed. The remaining areas are spatially clustered and considered continuous if they are spatially adjacent, a concave hull is built around these continuous areas, any remaining areas less than 0.025ha (250m2) are removed. Limited LIDAR coverage.	• EA 2m DTM LIDAR.	1	Potentially suitable for re-wetting.	• Greenspace – Transport[3]; • Unclassified; • Urban; and • Water.
				0	Not potentially suitable for re-wetting.	

[3] Roadside strips and rail verges. Usually very narrow and in some cases very long. Not potentially suitable for wetland creation.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Habitat Exclusions
Enhanced Urban	Greenspaces provide increased permeability and offer potential reduced surface run off levels when situated in mainly urban environments.	Urban land parcels are identified that spatially intersect with areas that are potentially suitable for Tree Planting, Reed Beds or SUDS, as described in JBA Working With Natural Processes Opportunity Mapping.	• JBA – Urban Loss Improvement; and • OS MasterMap.	0	Parcels which do not intersect with Urban improvement areas.	• Agricultural; • Greenspace; • Semi Natural Grassland; • Unclassified; • Urban – Buildings, Roads, Rail; • Water; and • Woodland.
				1	Parcels which intersect with Urban improvement areas.	
Rural Losses	Through modifications to the land use and landscape management techniques, damaged soil structure can be improved to increase soil moisture capacity.	The identification of land with damaged soil structure which has the potential for increased soil moisture levels through changes to landscape management techniques and processes.	• OS MasterMap.	1	Parcels which are designated as Greenspace or semi natural grassland.	• Greenspace – Private Garden; • Unclassified; • Urban; • Water; and • Woodland.
				2	Parcels which are designated as agriculture.	

Amenity

The following attributes are assessed; Tree Canopy Deficiency Areas (TCDA) – Greenspace, Tree Canopy Deficiency Areas (TCDA) – Urban and placemaking. Data provided by the City of Trees 2015 to 2017 study on Green Infrastructure for Water Mapping for the Irwell and Upper & Lower Mersey Catchments has been utilised for the tree canopy analysis. Trees and woodland provide a variety of benefits, including health through reduced stress and anxiety, health recovery and improvements to mental health and wellbeing.

Opportunity Area	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Tree Canopy Deficiency Areas (TCDA) - Greenspace (Greening the Pale Green) 	Trees provide amenity value to greenspaces. The Greater Manchester tree canopy average is 16%[4], where parcels of greenspace fall below this average there may be opportunities for tree planting to increase their amenity value.	Greenspace habitat types were intersected with tree crown data from the GM Tree Audit. Total coverage of tree canopy was calculated per Greenspace parcel. Parcels were scored based on their tree canopy percentage. Limited Tree coverage.	• OS MasterMap; and • GM Tree Audit.	0	Greater than 10%	• Unclassified; • Urban; • Water; and • Woodland.
				1	10% or less	
Tree Canopy Deficiency Areas (TCDA) - Urban (Greening the	Trees provide amenity value to urban land. The Greater Manchester tree canopy average is	Urban habitat types were filtered to exclude the following subtypes: Buildings, Roads, Rail. Tree canopy cover percentage was calculated per parcel. Each parcel was scored based on	• OS MasterMap; and • GM Tree Audit.	0	Greater than 2%	• Agricultural; • Greenspace; • Unclassified; • Urban – Buildings, Rail, Roads;

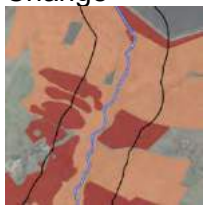
[4] UrbanTreeCover.org

Opportunity Area	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Grey) 	16%[5], where parcels of urban land fall below this average there may be opportunities for tree planting to increase amenity value.	their tree canopy percentage. Limited Tree coverage.		1	2% or less	• Water; and • Woodland.
Placemaking 	Where greenspace and woodland are in close proximity to HMWB and contain Public Rights of Way (PRoW) and/or Greater Manchester Cycle Routes it is assumed that more people will come into contact with placemaking interventions and thus such interventions would have greater benefits for people.	Greenspace & Woodland parcels that are within 20m of HMWB (waterfront) and contain a PRoW or a Cycle Route are identified.	• PRoW (Public Right of Way) data; and • GM Cycle Routes.	0	Not waterfronted & Cycle Route or PRoW	• Agricultural; • Unclassified; • Urban; and • Water.
				1	Waterfronted & Cycle Route or PRoW	

[5] UrbanTreeCover.org

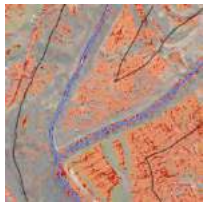
Carbon Sequestration

The following attributes are assessed; soil sequestration capacity, potential for agricultural land use change, potential for urban and amenity Land use change, agricultural land class and land potentially used for re-wetting/ wetland creation. The methods broadly follow those piloted by the West Country Rivers Trust, adapted to the IMC, and with the addition of an attribute relating to the specific value of wetland habitat creation in addressing Water Framework Directive (WFD) goals.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Soil Sequestration Capacity 	Some soils have a higher natural capacity to sequester carbon than others. While any soil can sequester carbon, clay or peat based soils have the greatest capacity to lock up organic material, while lighter sandy or loamy soils have lower capacity for increased sequestration.	Due to the low spatial resolution of the data, and the urban environment in and around the waterbody. It is assessed that the soil type is poor for sequestering carbon. Therefore the poorest category score is assigned to each Agricultural, Greenspace, and Woodland habitat parcels for categories.	• European Soil Database v2.0; and • OS MasterMap.	0	Sandy	• Urban – Buildings, Rail, Roads.
				1	Loam	
				2	Gley	
Potential for Agricultural Land Use Change 	Step-change increases in carbon sequestration can be achieved by moving land from arable to woodland.	Habitat parcels scored on the opportunity based on the broad “number of steps” to woodland.	• OS MasterMap.	0	Woodland	• Greenspace; • Unclassified; • Urban; • Water; and • Woodland.
				1	Permanent Grassland	
				2	Agricultural	

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Potential for Urban and Amenity Land Use Change 	Step-change increases in carbon sequestration can be achieved by moving land to woodland.	Habitat parcels scored on the opportunity based on the broad "number of steps" to woodland.	• OS MasterMap.	0	Woodland	• Agricultural; • Unclassified; • Water; and • Woodland.
				1	Greenspace	
				2	Urban	
Land Potentially Used for Re-Wetting/ Wetland	This category identifies opportunities for creating or restoring wetlands where land can hold more water and reduce flood risk. The greatest opportunities are associated with land	Using SAGA-GIS a Topographic Wetness Index is generated with EA 2m DTM LIDAR. The generated raster data values are Normalised. Areas with high "Wetness" are extracted, vectorised, and areas < 16m2 are removed. The remaining areas are spatially clustered and considered continuous if	• EA 2m DTM LIDAR.	1	Potentially suitable for re-wetting.	• Greenspace – Transport[6]; • Private Gardens; • Unclassified; • Urban; and • Water.

[6] Roadside strips and rail verges. Usually very narrow and in some cases very long. Not potentially suitable for wetland creation.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Creation 	that has a high tendency to be seasonally/ permanently wet. The analysis identified areas of land adjacent of water courses with currently limited or low flow paths, to highlight land with the potential for wetland creation.	they are spatially adjacent, a concave hull is built around these continuous areas, any remaining areas less than 0.025ha (250m2) are removed. Limited LIDAR coverage.		0	Not potentially suitable for re-wetting.	

Leisure and Recreation

The following attributes are assessed; proximity to people, private greenspace, proximity to GMSF strategic development sites and proximity to schools. Proximity and access to good quality greenspaces is a core aim of national and local government policy. Benefits to health include improved mental health and wellbeing, reduced cardiovascular issues, and reduced obesity. Accessible greenspaces provide locations for rest, relaxation as well as increased physical activity and participation sports.

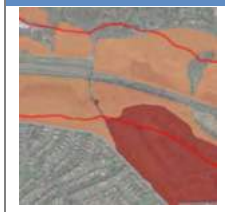
The Accessible Natural Greenspace Standard (ANGSt) produced by Natural England recommends that everyone, wherever they live, should have accessible natural greenspace:

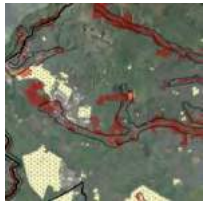
- Of at least 2 hectares in size, no more than 300 metres (5 minutes' walk) from home;
- At least one accessible 20 hectare site within two kilometres of home;
- One accessible 100 hectare site within five kilometres of home; and
- One accessible 500 hectare site within ten kilometres of home; plus
- A minimum of one hectare of statutory Local Nature Reserves per thousand population.

As suggested in the Companion Guide to PPG17, it is appropriate for sites smaller than 0.2ha not to be included in audits of local open space provision, therefore they have been excluded from this analysis. Although superseded, PPG17's Companion Guide for carrying out open space assessments has not yet been replaced and can still be considered as best practice.

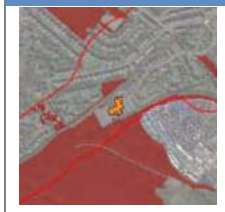
Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Proximity to People	Where residential properties are located within close proximity land that provide formal and informal leisure and recreation	Using OS AddressBase, greenspace and woodland within 500m and 300m of residential addresses are identified. An additional point is added if the asset falls within a Lower Super Output Area	• OS AddressBase • ONS Indices of Multiple Deprivation; and	0	Not Within 500m	• Greenspace – Transport[7]; • Greenspace parcels < 0.2 ha; • Agricultural;

[7] Roadside strips and rail verges offer little leisure & recreational value.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
	opportunities (greenspace and woodland) the greater the opportunities for local residents to be engaged in leisure and recreation and derive the associated health benefits. All residential addresses within the IMC are included, but only parcels within the 100m study area are scored. Natural England considers that accessible natural green space can provide opportunities for activities to improve health through physical activity and play.	(LSOA) that is ranked in the lower 20% in the Indices of Multiple Deprivation (IMD). The IMD_DECILE attribute within the IMD indicates which 10% block a particular LSOA would fall into. The lower the IMD_DECILE the more deprived a LSOA. For example: IMD_DECILE = 1 | 0 - 10% IMD_DECILE = 2 | 10 - 20% IMD_DECILE = 3 | 20 - 30%	• Lower Super Output Area (LSOA).	1	Within 500m & IMD Decile ≥ 3	• Unclassified; • Urban; and • Water.
				2	Within 500m & IMD Decile ≤ 2	
				2	Within 300m & IMD Decile ≥ 3	
				3	Within 300m & IMD Decile ≤ 2	

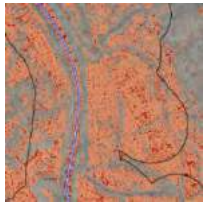
Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Proximity to Strategic Housing and Economic Availability Assessment Sites 	Areas of Greenspace, Woodland, and Semi Natural Grassland within close proximity to strategic development sites will have greater opportunities for local residents, workers and visitors to be engaged in leisure and recreation and derive the associated health benefits.	Greenspaces, Woodlands, and Semi Natural Grassland are spatially clustered with a tolerance of 50m. Any clusters smaller than 20 hectares are removed, any remaining clusters that are within 2km of Housing, Office or Industrial Allocation Sites are scored.	• OS MasterMap; and • Housing and Economic Availability Assessment Sites	0	Not Within 2km	• Greenspace – Transport[8]; • Greenspace parcels < 0.2 ha; • Agricultural; • Unclassified; • Urban; and • Water.
				1	Within 2km	
Proximity to Schools	Areas of greenspace, within close proximity to schools will have greater opportunities for school children and families to be engaged	Schools are identified using OS MasterMap. Greenspaces are then identified and scored that fall within 300m schools.	• OS MasterMap.	0	Not Within 300m	• Greenspace – Transport[9]; • Greenspace parcels < 0.2 ha; • Agricultural;

[8] Roadside strips and rail verges could link spatially distance areas of Greenspace when considered as part of the cluster.
[9] Roadside strips and rail verges offer little leisure & recreational value.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
	in leisure and recreation. Access to high quality open spaces is critically important to promoting children's physical health and wellbeing.			1	Within 300m	• Unclassified; • Urban; • Water; and • Woodland.

Biodiversity and Ecological Networks

The following attributes have been assessed; land with potential for wetland creation, proximity to habitats, Nature Improvement Areas, and publicly accessible open space. Interventions to create or improve semi-natural habitats in land parcels with these attributes have the greatest opportunity to extend existing ecological networks and/or increase their resilience. The methods broadly follow those piloted by the West Country Rivers Trust, adapted to the IMC, and with the addition of an attribute relating to the specific value of wetland habitat creation in addressing WFD goals.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Land Potentially Used for Re-Wetting/ Wetland Creation 	Land adjacent or close to water courses has the potential for wetland creation dependent on the land type and characteristics. The analysis identified areas of land adjacent of water courses with currently limited or low flow paths, to highlight land with the potential for wetland creation.	Using SAGA-GIS a Topographic Wetness Index is generated with EA 2m DTM LIDAR. The generated raster data values are Normalised. Areas with high "Wetness" are extracted, vectorised, and areas < 16m2 are removed. The remaining areas are spatially clustered and considered continuous if they are spatially adjacent, a concave hull is built around these continuous areas, any remaining areas less than 0.025ha (250m2) are removed. Limited LIDAR coverage.	• EA 2m DTM LIDAR.	1	Potentially suitable for re-wetting.	• Greenspace – Transport[10]; • Unclassified; • Urban; and Water.
				0	Not potentially suitable for re-wetting.	

[10] Roadside strips and rail verges. Usually very narrow and in some cases very long. Not potentially suitable for wetland creation.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Proximity to Habitats 	The protection and enhancement of ecologically important habitats is a core aim of the project. Through identifying the close proximity of habitats to water courses the potential opportunities to expand sites are identified. Greater benefits can be obtained through the extension of existing sites as opposed to the creation of new sites.	Greenspace habitats are identified where they fall within 10m of Ecological Designations (see master data table appendix, Section 41 habitats, or Local Designations (Biological Heritage Sites and Sites of Biological Importance). Spatially coincident areas are removed. Leaving parcels that could potentially be upgraded to hold either Section 41 or Ecological Designation status.	• OS MasterMap; • Ecological Designations • Section 41 Habitats; and • Local Designations .	1	Greenspace adjacent to Section 41 Habitat or Local Designation.	• Unclassified; • Urban; and • Water.
				2	Greenspace adjacent to Ecological Designations	
Nature Improvement Areas (NIA) 	Location and proximity of Natural improvement areas within the study boundary.	Habitat parcels are identified that intersect with GMEU Nature Improvement Areas.	• Nature Improvement Areas.	0	Parcel does not intersect NIA.	• Private Gardens; • Unclassified; • Urban; and • Water.
				1	Parcel intersects NIA.	
Openspace that is Publicly	Identification of greenspaces that are publicly accessible, where projects to improve nature	Using OS Open Greenspace Sites, identify habitat parcels that intersect with OS Open Greenspace Sites.	• OS MasterMap; and	0	Parcel does not intersect with Greenspace Site.	• Private Gardens; • Unclassified; • Urban; and • Water.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Accessible 	conservation will increase the engagement of people with nature and opportunities for education and stewardship of the natural world		• OS Open Greenspace Sites.	1	Parcel does intersect with Greenspace Site.	
Transport Corridors	Transport corridors are linear strips of land adjacent to roads, railway lines, and cycle paths. The mosaic of grassland, scrub, shelter belt and tall herb habitats usually associated with these transport corridors provide important refugia and wildlife links, facilitating the dispersal of plants and animals.[11]	Using OS MasterMap, all parcels are identified that are classified as Natural and either Roadside or Rail.	• OS MasterMap.	0	Non Transport Corridor	• Urban.
				1	Transport Corridor	

[11] https://www.newcastle.gov.uk/sites/default/files/wwwfileroot/planning-and-buildings/planning/baphap4.pdf

Air Quality

The following attributes have been assessed; modelled background pollution data PM2.5 distribution and primary road numbers within waterbody catchment. The analysis identifies areas within our study area with the highest concentration of PM 2.5 µg m3 in relation to waterbody catchments with the highest number of roads. Therefore the greater the number of roads, the more opportunity there is attempt to displace cycling / running / walking commuting from roads to greenspaces / green routes.

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Modelled Background Pollution Data PM2.5 Distribution 	Medical evidence shows that many thousands of people still die prematurely every year because of the effects of air pollution. Air pollution from man-made particles is currently estimated to reduce average UK life expectancy (from birth) by six months. Moreover, it is now firmly established that air pollution (particulate matter, sulphur dioxide and ozone) contributes to thousands of hospital admissions per year[12].	Using Modelled Background Pollution Data at 1km x 1km resolution, a raster is generated then rescaled, using Cubic interpolation, to 10m x 10m. This is then reclassified into 3 scored bands.	• Modelled Background Pollution Data PM2.5.	0	≤ 8 µg/m^3	• Urban; • Unclassified; and • Water.
				1	≤ 10 µg/m^3	
				2	> 10 µg/m^3	

[12] https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2015_issue_1.pdf

Attribute	Reason	Methodology				
		Method	Data Layers	Score		Exclusions
Number of Primary Roads within Waterbody Catchment 	Identifying Waterbody catchments that contain the highest number of primary roads (A, B, and Primary classified roads). Catchments with the highest number of roads potentially has more opportunity to displace cycling, running, walking commutes from roads to greenspaces or green routes.	With OS Vector Map Local, primary roads were combined to create a single continuous length of road per road number. E.g. A57, B5229. This is to prevent stretches of road that are one junction in length from being counted multiple times. Each stretch of road was cut to EA Waterbody Catchments, then the total number of distinct primary roads are counted. If the catchment boundary cut would mean that a road leaves and re-enters the catchment, it is only counted once. Motorways are excluded. Under the highway code, cyclists and pedestrians are prohibited. And therefore would not be used for cycling, running, or walking commutes.	• OS Vector Map Local; and • EA Waterbody Catchments.	1	1 – 6 Primary Roads	• Urban; • Unclassified; and • Water; and • Road type: motorways.
				2	7 – 12 Primary Roads	
				3	> 13 Primary Roads	

APPENDIX F: MAPPING TOOL USER GUIDE

Appendix F: Mapping Tool User Guide

This appendix provides instructions and details on how to understand and interpret the opportunity mapping data generated from the project and accessed through MappingGM. This user guide should be read in conjunction with:

- *Irwell Management Catchment Natural Capital Account and Ecosystem Services Opportunity Mapping*
- *Appendix E: Opportunity Assessment Methods and Mapping Protocols*

Opportunity Mapping

This study identifies, for each land parcel in the study area, the opportunities that changes in land use or management could bring in terms of improved ecosystem services (ESS). Opportunity arises on land which, given its physical, social, economic, geographical and cultural characteristics, offers potential to intervene and improve ESS functioning and thus uplift natural capital value. Opportunity arises where there is a combination of feasibility and need.

The opportunity mapping data layer includes the outputs scores for each ESS along with each services constituent attributes. ESS are made up of several 'attributes' which analyse different aspects of each service. For example, the water quality service is made up of an assessment of attributes including: land connectivity, hydrological connectivity, slope, soil characteristics, land use and consented discharge locations. Across all services and attributes the higher the score the higher the potential for improving the natural capital and ESS value of the parcel.

Each land parcel is determined through the use OS MasterMap. Within the study there does exist parcels of MasterMap with no classification, however this represents 1.04% of the total area of parcels within the study. The study includes land parcels with no opportunity for improvement and a score of 0, for example, where there is no need for ESS uplift or the land parcel does not lend itself to the intervention in question.

Some parcels of MasterMap do not have classifications, and so cannot be assigned a habitat type unless additional data is available through ground-truthing or local knowledge. This usually occurs where land is in transition (including in this case, the creation of an urban flood drainage basin in Salford which was undergoing engineering works at the time of the relevant Mastermap survey). In the study area, there are 124 hectares of unclassified parcels (0.74% of the total classified habitat types). Given these potential issues with MasterMap it is important to highlight

the significance of local knowledge, and how this combined with the MasterMap data provides the most in depth analysis.

For each ESS and attribute, there are several types of measures which could be implemented to deliver the opportunity and improve the natural capital and ESS value. For example, to improve water quality, measures could include tree planting or reed bed establishment to filter sediment or intercept polluted surface water on its flow to the waterbody.

All scores, across all services are stored within the GIS opportunity mapping data layer by OS MasterMap parcel, the layer contains the following information:

- Broad Habitat Type;
- Sub Habitat Type;
- Ecosystem Attributes Score(s);
- Ecosystem Service Score(s); and
- Total Combined Ecosystem Service Score(s).
- Ecosystem Groups (Amenity, Air Quality, Carbon Sequestration, Ecological Networks, Flood Mitigation, Leisure & Recreation, Water Quality).

The table below details all services and attributes included within the opportunity mapping data layer.

Ecosystem Services	Attributes
Water quality	• Land connectivity • Hydrological connectivity • Slope • Soil characteristics • Land use • Consented discharge locations
Flood risk mitigation	• Size of upstream catchment • Runoff Attenuation Features (RAF) • Roughening up the landscape • Land potentially used for re-wetting / wetland creation • Enhanced urban • Rural losses
Amenity	• Tree Canopy Deficiency Areas – Greenspace • Tree Canopy Deficiency Areas – Urban • Placemaking
Leisure and recreation	• Proximity to people

Ecosystem Services	Attributes
	• Proximity to strategic development sites • Proximity to schools
Biodiversity and ecological networks	• Land potentially used for re-wetting / wetland creation • Proximity to habitats • Nature Improvement Areas (NIA) • Open space that is publicly accessible • Transport corridors
Air quality	• Modelled background pollution data PM2.5 distribution • Number of primary roads within waterbody catchment
Carbon sequestration	• Soil sequestration capacity • Potential for agricultural Land use change • Potential for urban and amenity Land use change • Land potentially used for re-wetting / wetland creation

Step by Step Guide

The step by step instructions below are structured to take users through using and interacting with the opportunity mapping data layer.

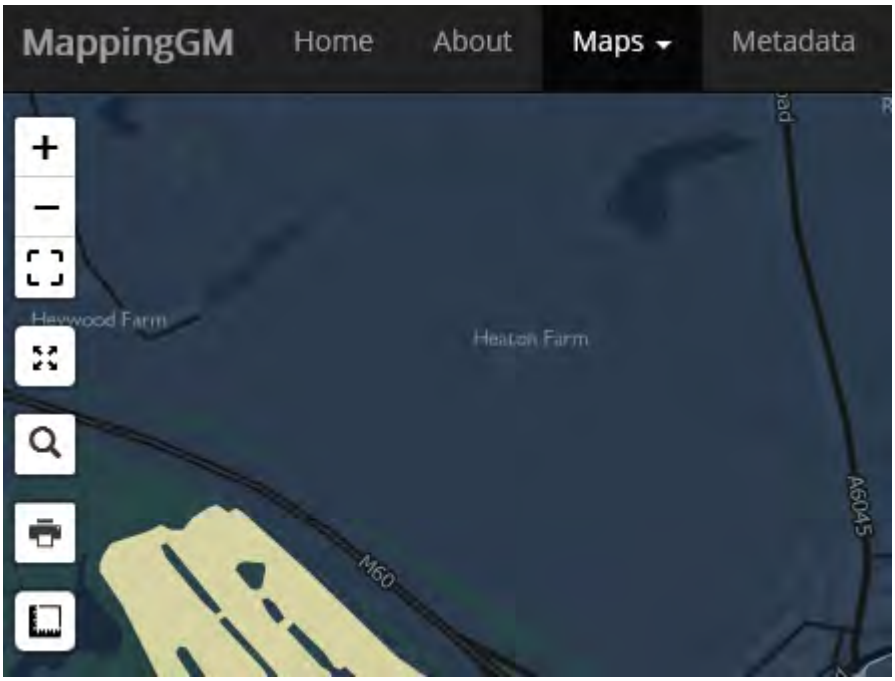
1. Open MappingGM https://mappinggm.org.uk/, and select options to 'view the map'.

2. Using the layer options window on the right hand side of the screen, turn on the Irwell Ecosystem Service opportunity mapping data layer. On the screen the user will see all 200,000+ land parcels within the study boundary of the project.

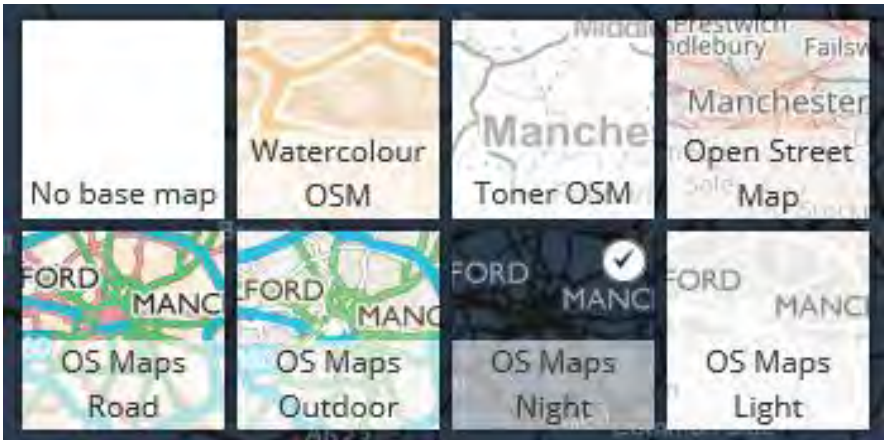
3. The drop down filter option in the layer allows the user to amend the information displayed in the map. The user can select from the 3 options;

   - Ecosystem Service Score: Score range from Low (0) to High (27) for the combined ESS Score.
   - Broad Habitat Type: Displays the broad habitat types recorded in the study.
   - Sub Habitat Type: Displays all sub habitat types recorded in the study.
   - Ecosystem Service Groups: (Amenity, Air Quality, Carbon Sequestration, Ecological Networks, Flood Mitigation, Leisure & Recreation, Water Quality).

4. Use the tools on the top left hand side of the screen to navigate the map.



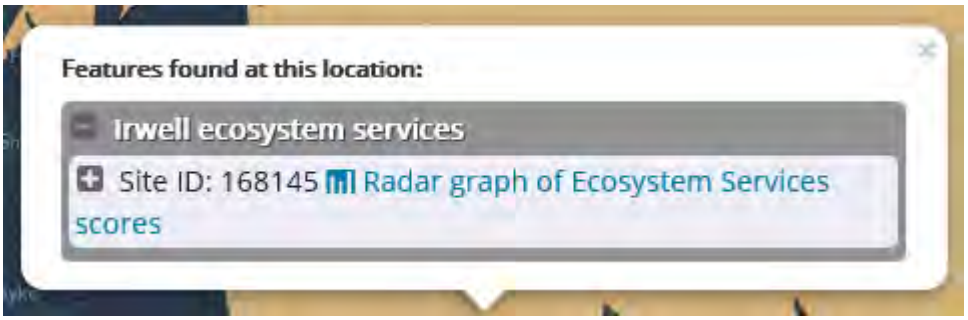
5. The mapping background can be amended to the user's requirements through the various selection options at the bottom right hand side of the screen. If the user hovers the cursor over the small box, various other mapping options will appear for selection.



6. Through using the layer options on the right hand side of the screen, the user is able to overlay the Ecosystem Service Opportunity Mapping Layer with all other layers available in MappingGM.

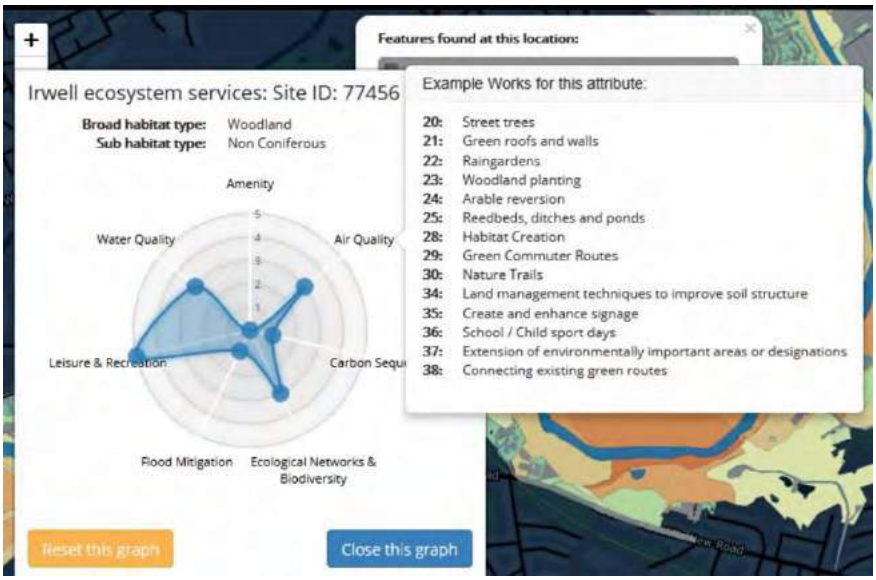
7. To access the details relating to any land parcel within the study, the user must click on a land parcel on the map. Given that some land parcels are small size, it is advised the users zoom into the map significantly to avoid selecting multiple parcels.

8. If the user clicks on any land parcel within the layer a pop up window will appear on screen. This window will display the summary information relating the parcel and link to the Radar Graph.



9. If the user clicks on the link to the Radar chart from the summary box, a radar chart will appear on the left hand side of the screen. The Radar chart will display the scores for each Ecosystem Service.

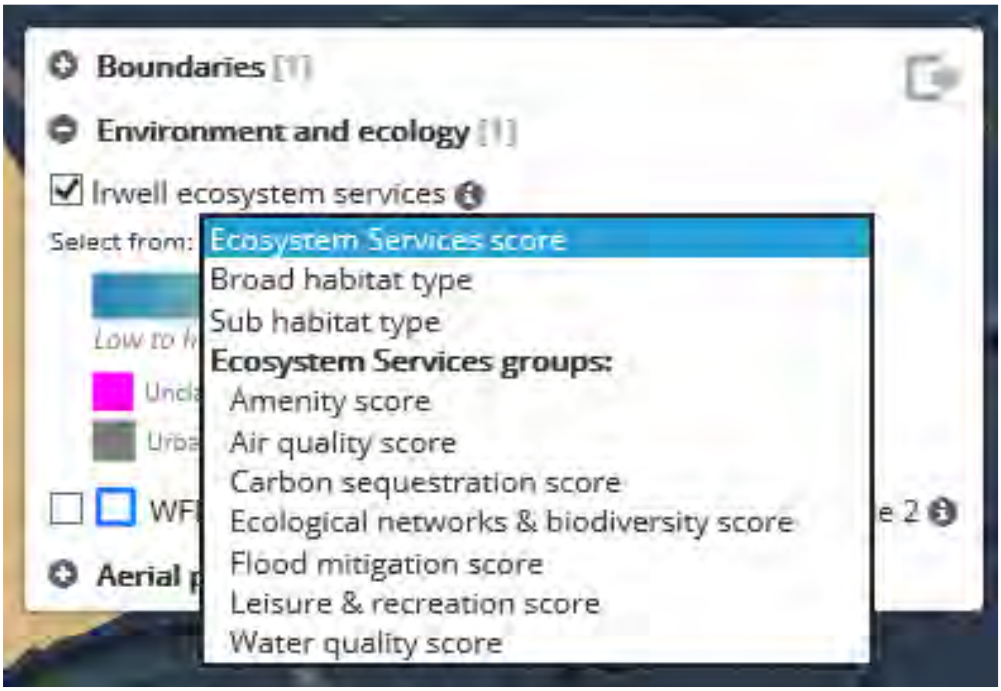
10. If the user hovers the cursor over each Ecosystem Service, the user will see a series of suggested potential improvement example works. This list is not inclusive of all options, and the items listed are there to offer suggestions on how each Ecosystem Service score could potentially be increased.



11. Using the Radar Chart it is also possible for the user to see the scores for the attributes of each Ecosystem Service. For example (as shown below), if the user clicks on the Leisure and Recreation Ecosystem Service, the Radar chart will update to show the scores for each individual attribute of the Leisure and Recreation Ecosystem Service; these will include Proximity to People, Proximity to Strategic Development Sites and Proximity to Schools.

12. If the user wishes to return to the view of all Ecosystem Service Scores, then the “reset this graph” button will return the user to the upper level.

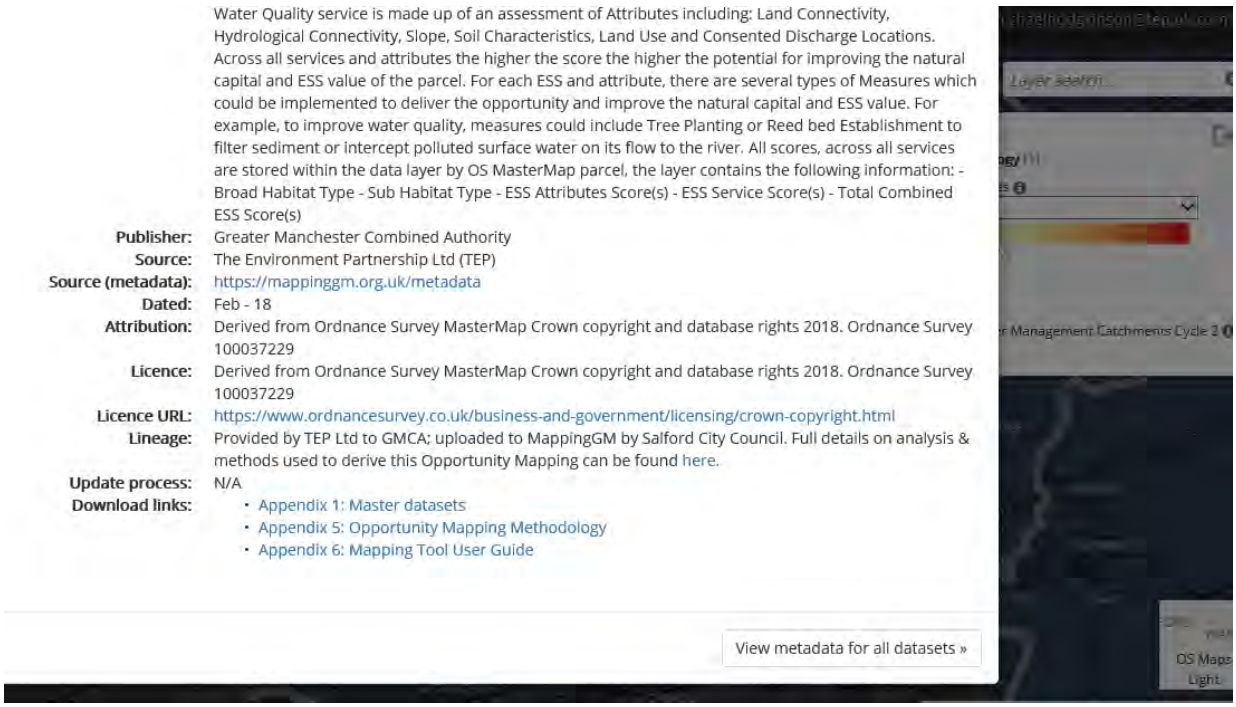
13. If a user is interested in just focussing one of the seven Ecosystem Service in the scope of the project then the user has the option to select a single Ecosystem Service. Using the main layer option window (right hand side of the screen), the user can use the drop down list to select the relevant Ecosystem Service. Once selected the map will update to show only the scores for the selected Ecosystem Service.



14. The above process can be completed for all land parcels within the study area.

15. Additional documentation guidance can be accessed directly from within MappingGM. If the user clicks on the 'i' symbol next to the Irwell Ecosystem Services Layer on the main layer option window the user will be able to view the metadata for the layer. This includes links to three documents:

    - Appendix 1: Master Datasets
    - Appendix 5: Opportunity Mapping Methodology
    - Appendix 6: Mapping tool User Guide



If any user would like to keep us updated on sites or would be interested in developing the mapping tool further then please contact Krista Patrick on the details below.

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Natural Capital Coordinator
GM Environment Team
Greater Manchester Combined Authority (GMCA)
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APPENDIX G: NATURAL CAPITAL ACCOUNTS BY WATERBODY AND DISTRICT

Appendix G: Natural Capital Accounts by Waterbody and District

Natural Capital Account by Waterbody

The table details key statistics for the waterbodies within the study area. The table contains the Natural Capital Accounts for each waterbody for each ecosystem service (ESS) in the scope of the project. Values are rounded to two significant digits. Values for timber production are not reported separately by waterbody since exact locations of timber harvesting locations are not know. Bracketed values indicate costs.

Waterbody / Catchment Code	Waterbody / Catchment	Population	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk	Water Abstraction	Agriculture	Total
gb112069064530	Tonge	14,000	2,300,000	1,200,000	830,000	610,000	8,100	180,000	(550,000)	400	1,500	4,600,000
gb112069060840	Irwell (Roch to Croal)	41,000	5,200,000	2,700,000	1,100,000	2,100,000	34,000	290,000	(4,700,000)	4,100,000	9,400	11,000,000
gb112069061120	Wince Brook	34,000	2,600,000	1,400,000	2,500,000	2,300,000	7,500	490,000	(37,000)	0	110	9,300,000
gb112069061131	Irk (Wince to Irwell)	120,000	22,000,000	11,000,000	6,700,000	6,100,000	96,000	660,000	(1,200,000)	53,000	5,000	45,000,000
gb112069061151	Medlock (Source to Lumb Brook)	120,000	12,000,000	6,100,000	4,200,000	6,600,000	80,000	680,000	(3,100,000)	27,000	35,000	26,000,000
gb112069061152	Medlock (Lumb Brook to Irwell)	100,000	15,000,000	8,000,000	4,600,000	6,300,000	45,000	490,000	(580,000)	71,000	3,600	34,000,000
gb112069061161	Irk (Source to Wince Brook)	68,000	5,300,000	2,800,000	2,300,000	3,500,000	35,000	700,000	(300,000)	0	15,000	14,000,000
gb112069064560	Astley Brook (Irwell)	30,000	1,600,000	680,000	530,000	570,000	17,000	290,000	(750,000)	8,800	44,000	2,900,000
gb112069064610	Kirklees Brook	17,000	1,400,000	750,000	210,000	950,000	11,000	390,000	(360,000)	8,900	25,000	3,400,000
gb112069064641	Irwell (Cowpe Bk to Rossendale STW)	8,200	1,100,000	590,000	130,000	330,000	18,000	240,000	(2,000,000)	61,000	6,900	560,000
gb112069061430	Folly Brook and Salteye Brook.	62,000	9,200,000	4,600,000	4,300,000	4,800,000	57,000	220,000	(2,000,000)	7,400	2,900	21,000,000
gb112069061451	Irwell (Croal to Irk)	120,000	26,000,000	14,000,000	7,200,000	9,100,000	120,000	930,000	(1,400,000)	97,000	16,000	56,000,000
gb112069061452	Irwell / Manchester Ship Canal	250,000	31,000,000	16,000,000	10,000,000	16,000,000	40,000	3,000	(3,400,000)	610,000	9,700	70,000,000
gb112069064540	Middle Brook	79,000	5,900,000	2,900,000	3,300,000	3,300,000	41,000	580,000	(2,700,000)	410	21,000	13,000,000
gb112069064550	Croal (including Blackshaw Brook)	55,000	4,200,000	2,200,000	1,300,000	2,200,000	20,000	330,000	(33,000)	57,000	20,000	10,000,000
gb112069064570	Eagley Brook	24,000	1,500,000	790,000	460,000	650,000	16,000	440,000	(310,000)	8,800	53,000	3,600,000
gb112069064580	Bradshaw Brook	34,000	3,300,000	1,800,000	690,000	1,000,000	27,000	600,000	(380,000)	10,000	76,000	7,100,000
gb112069064600	Roch (Spodden to Irwell)	93,000	9,100,000	4,100,000	2,100,000	3,600,000	52,000	800,000	(2,400,000)	2,400,000	18,000	20,000,000
gb112069064620	Irwell (Rossendale STW to Roch)	42,000	5,200,000	2,100,000	830,000	1,500,000	30,000	1,200,000	(6,100,000)	6,200,000	130,000	11,000,000
gb112069064650	Ogden	11,000	1,300,000	690,000	130,000	340,000	20,000	550,000	(2,000,000)	46,000	78,000	1,200,000
gb112069064660	Irwell (Source to Whitewell Brook)	9,500	2,400,000	1,200,000	170,000	410,000	35,000	410,000	(2,500,000)	340,000	11,000	2,500,000
gb112069064670	Whitewell Brook	14,000	1,600,000	830,000	170,000	390,000	22,000	260,000	(1,100,000)	28,000	13,000	2,200,000
gb112069064680	Limy Water	7,200	1,300,000	670,000	110,000	330,000	17,000	290,000	(660,000)	35,000	17,000	2,100,000
gb112069064690	Beal	37,000	3,400,000	1,800,000	1,500,000	2,400,000	26,000	560,000	(3,200,000)	1,100,000	25,000	7,600,000

Natural Capital Account by District

The table details key statistics for the Districts within the project study area. The table contains the Natural Capital Accounts for each district for each ESS in the scope of the project. Values are rounded to two significant digits. Values for timber production are not reported separately by waterbody since exact locations of timber harvesting locations are not know. The districts of Burnley, Chorley, Hyndburn, and Calderdale are excluded from the table given that less than 10% of their district area overlaps with the catchment. Bracketed values indicate costs.

Local Authority Code	Local Authority Name	Proportion of District in Catchment (%)	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk	Water Abstraction	Agriculture	Total
E06000008	Blackburn with Darwen	39	6,400,000	3,300,000	670,000	2,200,000	120,000	720,000	(2,500,000)	4,500,000	140,000	16,000,000
E07000125	Rossendale	95	9,000,000	4,700,000	1,300,000	1,300,000	170,000	1,200,000	(8,500,000)	3,900,000	300,000	13,000,000
E08000001	Bolton	70	32,000,000	17,000,000	6,300,000	8,100,000	180,000	2,300,000	(4,500,000)	110,000	41,000	61,000,000
E08000002	Bury	100	25,000,000	13,000,000	6,500,000	9,500,000	190,000	3,000,000	(11,000,000)	5,700,000	200,000	52,000,000
E08000003	Manchester	49	37,000,000	19,000,000	11,000,000	15,000,000	44,000	220,000	(1,800,000)	590,000	510	82,000,000
E08000004	Oldham	51	13,000,000	6,600,000	7,600,000	9,800,000	62,000	2,400,000	(5,000,000)	1,600,000	48,000	36,000,000
E08000005	Rochdale	98	25,000,000	12,000,000	8,200,000	8,300,000	92,000	3,100,000	(9,600,000)	5,200,000	200,000	52,000,000
E08000006	Salford	64	27,000,000	14,000,000	9,700,000	13,000,000	86,000	590,000	(2,900,000)	710,000	2,200	63,000,000
E08000008	Tameside	21	10,000,000	5,300,000	3,800,000	5,200,000	26,000	440,000	(1,700,000)	220,000	12,000	23,000,000
E08000009	Trafford	20	6,100,000	3,200,000	3,400,000	6,800,000	14,000	100,000	(580,000)	430,000	7,900	20,000,000
	Total		190,000,000	98,000,000	59,000,000	8,000,000	1,000,000	14,000,000	(48,000,000)	23,000,000	1,000,000	420,000,000

Appendix H: Ecosystem Services Opportunity Assessment by Waterbody

Waterbody Details and Scores

The table details key statistics for the 27 waterbodies and their catchments within the project study area. The table contains each waterbody reference, name, number of parcels and overall area. Additionally, the table includes the minimum and maximum score range for Ecosystem Service (ESS) and over all combined score by waterbody.

Waterbody	Parcel No.	Area (ha)	Water Quality Min	Water Quality Max	Flood Mit. Min	Flood Mit. Max	Amenity Min	Amenity Max	Carbon Seq. Min	Carbon Seq. Max	Leisure & Rec. Min	Leisure & Rec. Max	Bio. & Eco Networks Min	Eco Networks Max	Air Quality Min	Air Quality Max	Overall ESS Min	Overall ESS Max
Irwell (Roch - Croal)	3423	447.81	1	8	1	4	1	2	1	5	1	5	1	4	2	4	**2**	**25**
Irk (Wince - Irwell)	14574	654.77	1	7	1	3	1	2	1	5	1	4	1	5	2	4	**2**	**23**
Medlock (Source – Lumb Brook)	6866	714.48	1	9	1	5	1	2	1	5	1	4	1	4	3	4	**3**	**25**
Medlock (Lumb Brook - Irwell)	6381	422.12	1	9	1	4	1	2	1	5	1	4	1	4	3	4	**3**	**25**
Irk (Source – Wince Brook)	12540	664.05	1	9	1	4	1	2	1	5	1	4	1	5	2	4	**2**	**26**
Folly Brook & Salteye Brook	4192	260.36	1	8	1	3	1	2	1	5	1	4	1	3	2	4	**2**	**22**
Irwell (Croal – Irk)	20369	1052.04	1	8	1	4	1	2	1	5	1	5	1	5	3	4	**3**	**25**
Irwell / Ship Canal (Irk Confluence – Upper Mersey)	9917	798.19	1	7	1	3	1	2	1	5	1	4	1	3	3	4	**3**	**19**
Tonge	2925	151.13	1	7	2	5	1	2	1	4	2	4	1	5	2	4	**4**	**24**
Middle Brook	11215	637.26	1	9	1	5	1	2	1	5	1	5	1	4	3	4	**3**	**26**
Croal (Inc. Blackshaw Brook)	2815	411.24	1	9	1	4	1	2	1	5	1	4	1	5	2	4	**2**	**25**
Astley Brook (Irwell)	4934	362.69	1	8	1	5	1	2	1	5	1	4	1	5	1	4	**1**	**23**
Eagley Brook	4042	672.27	1	8	1	5	1	2	1	5	1	4	1	5	1	3	**1**	**23**
Bradshaw Brook	5397	1366.28	1	9	1	5	1	2	1	5	1	4	1	5	2	3	**2**	**24**
Roch (Spodden – Irwell)	12775	826.17	1	9	1	4	1	2	1	5	1	4	1	5	3	4	**3**	**27**
Kirklees Brook	3672	555.3	1	9	1	5	1	2	1	5	1	3	1	5	1	4	**1**	**25**
Irwell (Rossendale STW – Roch)	14943	2126.18	1	8	1	5	1	2	1	5	1	5	1	4	3	4	**3**	**25**
Irwell (Cowpe Bk – Rossendale BTW)	4402	246.21	1	8	1	4	1	1	1	5	2	3	1	4	1	4	**1**	**21**
Ogden	4288	1000.52	1	8	1	5	1	1	1	5	2	3	1	4	2	4	**2**	**24**
Irwell (Source – Whitewell Brook)	9200	627.61	1	9	1	5	1	2	1	5	2	4	1	4	1	3	**1**	**23**
Whitewell Brook	5687	286.87	1	8	1	5	1	1	1	5	1	3	1	3	1	1	**1**	**21**
Limy Water	5925	310.97	1	8	1	5	1	1	1	5	2	3	1	3	1	2	**1**	**21**
Beal	13273	738.33	1	9	1	5	1	2	1	5	1	5	1	3	2	4	**2**	**24**
Naden Brook	2719	1411.01	1	9	1	5	1	2	1	5	1	3	1	4	1	4	**1**	**24**
Roch (Source – Spodden)	22428	1692.21	1	9	1	5	1	2	1	5	1	5	1	4	3	4	**3**	**26**
Spodden	8424	395.61	1	9	1	4	1	2	1	5	1	4	1	5	1	4	**1**	**24**

Waterbody Opportunity Assessment

The table below displays by waterbody whether the average opportunity score for each ESS in scope is above or below the Irwell Management Catchment (IMC) average (0 if below average, 1 if above). The total column provides an accumulative score across the services for each waterbody.

Waterbody	Water Quality	Flood Mitigation	Amenity	Leisure & Recreation	Biodiversity and Ecological Networks	Carbon Sequestration	Air Quality	Overall ESS	TOTAL
Astley Brook (Irwell)	0	1	0	1	1	0	0	0	**3**
Beal	0	0	1	0	0	1	0	0	**2**
Bradshaw Brook	1	1	1	0	1	1	0	1	**5**
Croal (including Blackshaw Brook)	0	1	1	0	1	1	0	1	**4**
Eagley Brook	1	1	0	0	1	0	0	0	**3**
Folly Brook and Salteye Brook	0	0	1	1	0	0	0	0	**2**
Irk (Source to Wince Brook)	0	0	0	0	0	0	0	0	**0**
Irk (Wince to Irwell)	0	0	1	1	1	0	0	0	**3**
Irwell (Cowpe Bk to Rossendale STW)	1	0	0	1	0	1	0	0	**3**
Irwell (Croal to Irk)	0	0	0	1	1	0	1	1	**3**
Irwell / Manchester Ship Canal (Irk to confluence with Upper Mersey)	1	0	0	0	0	0	1	1	**2**
Irwell (Roch to Croal)	0	0	1	0	1	0	0	1	**2**
Irwell (Rossendale STW to Roch)	0	1	0	0	1	1	1	1	**4**
Irwell (Source to Whitewell Brook)	1	0	1	1	0	1	0	0	**4**
Kirklees Brook	1	1	0	0	1	1	0	1	**4**
Limy Water	1	0	0	1	0	1	0	0	**3**
Medlock (Lumb Brook to Irwell)	1	0	1	1	0	0	1	1	**4**
Medlock (Source to Lumb Brook)	0	1	1	1	0	0	1	1	**4**
Middle Brook	0	0	0	1	0	0	1	1	**2**
Naden Brook	1	1	1	0	1	1	0	1	**5**
Ogden	1	1	0	0	0	1	0	1	**3**
Roch (Source to Spodden)	0	0	1	1	0	1	1	1	**4**
Roch (Spodden to Irwell)	0	0	1	1	1	0	1	1	**4**
Spodden	0	0	0	0	1	0	0	0	**1**
Tonge	0	1	0	1	1	0	0	1	**3**
Whitewell Brook	1	0	0	1	0	1	0	0	**3**

Appendix I: District Valuations and Opportunity Mapping

The table below details the key statistics from the Natural Capital Account and the opportunity mapping for each of the districts within the study area.

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
E06000008	Blackburn with Darwen	625	3 Waterbodies: Bradshaw Brook, Eagley Brook, Kirklees Brook.	16,000,000	1. Ecological Networks & Biodiversity – 1,283 ha 2. Water Quality – 1,062 ha 3. Flood Mitigation – 1,027 ha 4. Carbon Sequestration – 935 ha 5. Air Quality – 926 ha 6. Leisure & Recreation – 331 ha
E07000125	Rossendale	1,460	6 Waterbodies: Irwell, Limey Water, Naden Brook, Ogden, Spodden, Whitewell Brook	13,000,000	1. Water Quality – 2,726 ha 2. Ecological Networks & Biodiversity – 2721 ha 3. Flood Mitigation – 2,518 ha 4. Air Quality – 1,977 ha 5. Carbon Sequestration – 1,859 ha 6. Leisure & Recreation – 1,118 ha 7. Amenity – 280 ha
E08000001	Bolton	1,409	7 Waterbodies: Astley Brook, Bradshaw Brook, Croal, Eagley Brook, Irwell, Middle Brook, Tonge.	61,000,000	1. Ecological Networks & Biodiversity – 1,595 ha 2. Water Quality – 1,530 ha 3. Air Quality – 1,394 ha 4. Leisure & Recreation – 1,171 ha 5. Flood Mitigation – 975 ha 6. Carbon Sequestration – 411 ha 7. Amenity – 89 ha
E08000002	Bury	1,256	5 Waterbodies: Croal, Irk, Irwell, Kirklees Brook, Roch.	52,000,000	1. Ecological Networks & Biodiversity – 1,743 ha 2. Water Quality – 1,687 ha 3. Flood Mitigation – 1,225 ha 4. Leisure & Recreation – 921 ha 5. Carbon Sequestration – 846 ha 6. Air Quality – 808 ha 7. Amenity – 88 ha

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
E08000003	Manchester	599	3 Waterbodies: Irk, Irwell, Medlock.	82,000,000	1. Water quality – 491 ha 2. Biodiversity and ecological networks – 394 ha 3. Leisure and recreation – 358 ha 4. Flood risk mitigation – 159 ha 5. Air quality – 137 ha 6. Carbon sequestration – 15 ha 7. Amenity – 12 ha
E08000004	Oldham	761	3 Waterbodies: Beal, Irk, Medlock	36,000,000	1. Water quality – 990 ha 2. Biodiversity and ecological networks – 854 ha 3. Flood risk mitigation – 717 ha 4. Leisure and recreation – 598 ha 5. Air quality – 549 ha 6. Carbon sequestration – 383 ha 7. Amenity – 142 ha
E08000005	Rochdale	2,031	5 Waterbodies: Beal, Irk, Naden Brook, Roch, Spodden	52,000,000	1. Water quality – 3,394 ha 2. Biodiversity and ecological networks – 3,029 ha 3. Flood risk mitigation – 2,624 ha 4. Carbon sequestration – 2,043 ha 5. Leisure and recreation – 1,731 ha 6. Air quality – 857 ha 7. Amenity – 379 ha
E08000006	Salford	855	2 Waterbodies: Folly Brook and Salteye Brook, Irwell.	63,000,000	1. Water quality – 531 ha 2. Air quality – 494 ha 3. Biodiversity and ecological networks – 486 ha 4. Leisure and recreation – 462 ha 5. Flood risk mitigation – 203 ha 6. Amenity – 74 ha 7. Carbon sequestration – 35 ha
E08000008	Tameside	141	1 Waterbody: Medlock	23,000,000	1. Air quality – 250 ha 2. Biodiversity and ecological networks – 233 ha 3. Water quality – 227 ha

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
					4. Flood risk mitigation – 158 ha 5. Leisure and recreation – 137 ha 6. Carbon sequestration – 105 ha 7. Amenity – 14 ha
E08000009	Trafford	225	1 Waterbody: Irwell	20,000,000	1. Air quality – 190 ha 2. Water quality – 142 ha 3. Biodiversity and ecological networks – 138 ha 4. Leisure and recreation – 94 ha 5. Flood risk mitigation – 88 ha 6. Carbon sequestration – 67 ha

APPENDIX H: ECOSYSTEM SERVICES OPPORTUNITY ASSESSMENT BY WATERBODY

Appendix G: Natural Capital Accounts by Waterbody and District

Natural Capital Account by Waterbody

The table details key statistics for the waterbodies within the study area. The table contains the Natural Capital Accounts for each waterbody for each ecosystem service (ESS) in the scope of the project. Values are rounded to two significant digits. Values for timber production are not reported separately by waterbody since exact locations of timber harvesting locations are not know. Bracketed values indicate costs.

Waterbody / Catchment Code	Waterbody / Catchment	Population	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk	Water Abstraction	Agriculture	Total
gb112069064530	Tonge	14,000	2,300,000	1,200,000	830,000	610,000	8,100	180,000	(550,000)	400	1,500	4,600,000
gb112069060840	Irwell (Roch to Croal)	41,000	5,200,000	2,700,000	1,100,000	2,100,000	34,000	290,000	(4,700,000)	4,100,000	9,400	11,000,000
gb112069061120	Wince Brook	34,000	2,600,000	1,400,000	2,500,000	2,300,000	7,500	490,000	(37,000)	0	110	9,300,000
gb112069061131	Irk (Wince to Irwell)	120,000	22,000,000	11,000,000	6,700,000	6,100,000	96,000	660,000	(1,200,000)	53,000	5,000	45,000,000
gb112069061151	Medlock (Source to Lumb Brook)	120,000	12,000,000	6,100,000	4,200,000	6,600,000	80,000	680,000	(3,100,000)	27,000	35,000	26,000,000
gb112069061152	Medlock (Lumb Brook to Irwell)	100,000	15,000,000	8,000,000	4,600,000	6,300,000	45,000	490,000	(580,000)	71,000	3,600	34,000,000
gb112069061161	Irk (Source to Wince Brook)	68,000	5,300,000	2,800,000	2,300,000	3,500,000	35,000	700,000	(300,000)	0	15,000	14,000,000
gb112069064560	Astley Brook (Irwell)	30,000	1,600,000	680,000	530,000	570,000	17,000	290,000	(750,000)	8,800	44,000	2,900,000
gb112069064610	Kirklees Brook	17,000	1,400,000	750,000	210,000	950,000	11,000	390,000	(360,000)	8,900	25,000	3,400,000
gb112069064641	Irwell (Cowpe Bk to Rossendale STW)	8,200	1,100,000	590,000	130,000	330,000	18,000	240,000	(2,000,000)	61,000	6,900	560,000
gb112069061430	Folly Brook and Salteye Brook.	62,000	9,200,000	4,600,000	4,300,000	4,800,000	57,000	220,000	(2,000,000)	7,400	2,900	21,000,000
gb112069061451	Irwell (Croal to Irk)	120,000	26,000,000	14,000,000	7,200,000	9,100,000	120,000	930,000	(1,400,000)	97,000	16,000	56,000,000
gb112069061452	Irwell / Manchester Ship Canal	250,000	31,000,000	16,000,000	10,000,000	16,000,000	40,000	3,000	(3,400,000)	610,000	9,700	70,000,000
gb112069064540	Middle Brook	79,000	5,900,000	2,900,000	3,300,000	3,300,000	41,000	580,000	(2,700,000)	410	21,000	13,000,000
gb112069064550	Croal (including Blackshaw Brook)	55,000	4,200,000	2,200,000	1,300,000	2,200,000	20,000	330,000	(33,000)	57,000	20,000	10,000,000
gb112069064570	Eagley Brook	24,000	1,500,000	790,000	460,000	650,000	16,000	440,000	(310,000)	8,800	53,000	3,600,000
gb112069064580	Bradshaw Brook	34,000	3,300,000	1,800,000	690,000	1,000,000	27,000	600,000	(380,000)	10,000	76,000	7,100,000
gb112069064600	Roch (Spodden to Irwell)	93,000	9,100,000	4,100,000	2,100,000	3,600,000	52,000	800,000	(2,400,000)	2,400,000	18,000	20,000,000
gb112069064620	Irwell (Rossendale STW to Roch)	42,000	5,200,000	2,100,000	830,000	1,500,000	30,000	1,200,000	(6,100,000)	6,200,000	130,000	11,000,000
gb112069064650	Ogden	11,000	1,300,000	690,000	130,000	340,000	20,000	550,000	(2,000,000)	46,000	78,000	1,200,000
gb112069064660	Irwell (Source to Whitewell Brook)	9,500	2,400,000	1,200,000	170,000	410,000	35,000	410,000	(2,500,000)	340,000	11,000	2,500,000
gb112069064670	Whitewell Brook	14,000	1,600,000	830,000	170,000	390,000	22,000	260,000	(1,100,000)	28,000	13,000	2,200,000
gb112069064680	Limy Water	7,200	1,300,000	670,000	110,000	330,000	17,000	290,000	(660,000)	35,000	17,000	2,100,000
gb112069064690	Beal	37,000	3,400,000	1,800,000	1,500,000	2,400,000	26,000	560,000	(3,200,000)	1,100,000	25,000	7,600,000

Natural Capital Account by District

The table details key statistics for the Districts within the project study area. The table contains the Natural Capital Accounts for each district for each ESS in the scope of the project. Values are rounded to two significant digits. Values for timber production are not reported separately by waterbody since exact locations of timber harvesting locations are not know. The districts of Burnley, Chorley, Hyndburn, and Calderdale are excluded from the table given that less than 10% of their district area overlaps with the catchment. Bracketed values indicate costs.

Local Authority Code	Local Authority Name	Proportion of District in Catchment (%)	Recreation	Physical Health	Mental Health	Amenity	Carbon Seq.	Water Quality	Flood Risk	Water Abstraction	Agriculture	Total
E06000008	Blackburn with Darwen	39	6,400,000	3,300,000	670,000	2,200,000	120,000	720,000	(2,500,000)	4,500,000	140,000	16,000,000
E07000125	Rossendale	95	9,000,000	4,700,000	1,300,000	1,300,000	170,000	1,200,000	(8,500,000)	3,900,000	300,000	13,000,000
E08000001	Bolton	70	32,000,000	17,000,000	6,300,000	8,100,000	180,000	2,300,000	(4,500,000)	110,000	41,000	61,000,000
E08000002	Bury	100	25,000,000	13,000,000	6,500,000	9,500,000	190,000	3,000,000	(11,000,000)	5,700,000	200,000	52,000,000
E08000003	Manchester	49	37,000,000	19,000,000	11,000,000	15,000,000	44,000	220,000	(1,800,000)	590,000	510	82,000,000
E08000004	Oldham	51	13,000,000	6,600,000	7,600,000	9,800,000	62,000	2,400,000	(5,000,000)	1,600,000	48,000	36,000,000
E08000005	Rochdale	98	25,000,000	12,000,000	8,200,000	8,300,000	92,000	3,100,000	(9,600,000)	5,200,000	200,000	52,000,000
E08000006	Salford	64	27,000,000	14,000,000	9,700,000	13,000,000	86,000	590,000	(2,900,000)	710,000	2,200	63,000,000
E08000008	Tameside	21	10,000,000	5,300,000	3,800,000	5,200,000	26,000	440,000	(1,700,000)	220,000	12,000	23,000,000
E08000009	Trafford	20	6,100,000	3,200,000	3,400,000	6,800,000	14,000	100,000	(580,000)	430,000	7,900	20,000,000
	Total		190,000,000	98,000,000	59,000,000	8,000,000	1,000,000	14,000,000	(48,000,000)	23,000,000	1,000,000	420,000,000

APPENDIX I: DISTRICT VALUATIONS AND OPPORTUNITY MAPPING

Appendix I: District Valuations and Opportunity Mapping

The table below details the key statistics from the Natural Capital Account and the opportunity mapping for each of the districts within the study area.

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
E06000008	Blackburn with Darwen	625	3 Waterbodies: Bradshaw Brook, Eagley Brook, Kirklees Brook.	16,000,000	1. Ecological Networks & Biodiversity – 1,283 ha 2. Water Quality – 1,062 ha 3. Flood Mitigation – 1,027 ha 4. Carbon Sequestration – 935 ha 5. Air Quality – 926 ha 6. Leisure & Recreation – 331 ha
E07000125	Rossendale	1,460	6 Waterbodies: Irwell, Limey Water, Naden Brook, Ogden, Spodden, Whitewell Brook	13,000,000	1. Water Quality – 2,726 ha 2. Ecological Networks & Biodiversity – 2721 ha 3. Flood Mitigation – 2,518 ha 4. Air Quality – 1,977 ha 5. Carbon Sequestration – 1,859 ha 6. Leisure & Recreation – 1,118 ha 7. Amenity – 280 ha
E08000001	Bolton	1,409	7 Waterbodies: Astley Brook, Bradshaw Brook, Croal, Eagley Brook, Irwell, Middle Brook, Tonge.	61,000,000	1. Ecological Networks & Biodiversity – 1,595 ha 2. Water Quality – 1,530 ha 3. Air Quality – 1,394 ha 4. Leisure & Recreation – 1,171 ha 5. Flood Mitigation – 975 ha 6. Carbon Sequestration – 411 ha 7. Amenity – 89 ha
E08000002	Bury	1,256	5 Waterbodies: Croal, Irk, Irwell, Kirklees Brook, Roch.	52,000,000	1. Ecological Networks & Biodiversity – 1,743 ha 2. Water Quality – 1,687 ha 3. Flood Mitigation – 1,225 ha 4. Leisure & Recreation – 921 ha 5. Carbon Sequestration – 846 ha 6. Air Quality – 808 ha 7. Amenity – 88 ha

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
E08000003	Manchester	599	3 Waterbodies: Irk, Irwell, Medlock.	82,000,000	1. Water quality – 491 ha 2. Biodiversity and ecological networks – 394 ha 3. Leisure and recreation – 358 ha 4. Flood risk mitigation – 159 ha 5. Air quality – 137 ha 6. Carbon sequestration – 15 ha 7. Amenity – 12 ha
E08000004	Oldham	761	3 Waterbodies: Beal, Irk, Medlock	36,000,000	1. Water quality – 990 ha 2. Biodiversity and ecological networks – 854 ha 3. Flood risk mitigation – 717 ha 4. Leisure and recreation – 598 ha 5. Air quality – 549 ha 6. Carbon sequestration – 383 ha 7. Amenity – 142 ha
E08000005	Rochdale	2,031	5 Waterbodies: Beal, Irk, Naden Brook, Roch, Spodden	52,000,000	1. Water quality – 3,394 ha 2. Biodiversity and ecological networks – 3,029 ha 3. Flood risk mitigation – 2,624 ha 4. Carbon sequestration – 2,043 ha 5. Leisure and recreation – 1,731 ha 6. Air quality – 857 ha 7. Amenity – 379 ha
E08000006	Salford	855	2 Waterbodies: Folly Brook and Salteye Brook, Irwell.	63,000,000	1. Water quality – 531 ha 2. Air quality – 494 ha 3. Biodiversity and ecological networks – 486 ha 4. Leisure and recreation – 462 ha 5. Flood risk mitigation – 203 ha 6. Amenity – 74 ha 7. Carbon sequestration – 35 ha
E08000008	Tameside	141	1 Waterbody: Medlock	23,000,000	1. Air quality – 250 ha 2. Biodiversity and ecological networks – 233 ha 3. Water quality – 227 ha

Local Authority Code	Local Authority Name	Study Area in District (ha)	Waterbodies in District	Natural Capital Value (All ESS Combined)	Opportunities Above District Average (Service - Area)
					4. Flood risk mitigation – 158 ha 5. Leisure and recreation – 137 ha 6. Carbon sequestration – 105 ha 7. Amenity – 14 ha
E08000009	Trafford	225	1 Waterbody: Irwell	20,000,000	1. Air quality – 190 ha 2. Water quality – 142 ha 3. Biodiversity and ecological networks – 138 ha 4. Leisure and recreation – 94 ha 5. Flood risk mitigation – 88 ha 6. Carbon sequestration – 67 ha

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