Deliverable 1.4 Intervention Conclusions:

Manchester

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1 Executive Summary

This report details the interventions and outcomes of the **Manchester GrowGreen project**, funded as part of the European Commission's 2016 Smart Cities and Communities Call for "Demonstrating Innovative Nature Based Solutions in Cities". Along with **Manchester (UK)**, the project includes two other demonstration sites in the GrowGreen front runner cities: **Valencia (ESP) and Wroclaw (PL).** Together, they look at the ways Nature Based Solutions (NbS), in particular Sustainable Urban Drainage Systems (SuDS), can help adapt cityscapes to a changing climate.

The site for the Manchester Demonstration Project is in West Gorton, a city suburb three kilometres south east of the city centre. Previously an area dominated by heavy industry, the location has suffered from the challenges of deindustrialisation, including high levels of social deprivation, negative local health indicators, poorly maintained housing, as well as high unemployment. The planned regeneration of the area, to include new high quality housing, provided the opportunity to co-design a new space for public recreation and to demonstrate how NbS and SuDS options can support climate change adaptation and offer a range of positive social-economic benefits. The park design was based on the concept of a **"park that drinks water"**, inspired by the work of the GrowGreen partner, Manchester's twin city of **Wuhan (ROC).**

Baseline diagnostics within the project looked at climate, air and water quality, health indicators, water management, noise, green space and soil contamination, alongside social and economic indicators. This baseline was used to provide a robust evidence base and develop a set of Key Performance Indicators (KPIs). Whilst the driver was to improve climate and water resilience, there were a number of other co-benefits that could be achieved.

Community engagement was high on the agenda of this project, with participatory planning seen as an important element within it. The "Challenge" areas were determined through a process of co-design with stakeholders, including local residents. The University of Manchester (UNIMAN) led the monitoring and evaluation of the impact of the NbS intervention at West Gorton, the effectiveness in improving climate resilience along with the social and economic impact of the project.

The Park was designed with three interconnected areas, each with distinctive elements and NbS features:

- **Woodland** (north) - a planted swale, a bio-retention tree pit, a picnic/seating area, an informal play area with climbing wall, timber play features, and basketball court.
- **Meadow** (central) - meadow planting, orchard trees, picnic tables, edible hedgerows, exploration play and contact with nature through mounds and a stepping-stone trail. This zone also includes a planted raingarden and a series of long linear swales.
- **Community Plaza Garden** (south) - sensory planting, a flexible event space, community growing spaces and seating. This area includes permeable paving, a raingarden with bio-retention tree pit and a planted swale.

Monitoring was undertaken pre (2018-19) and post greening (2020 – 2022). The Park was developed as a "Living Lab" with research outcomes on the following areas: climate and water resilience, biodiversity, water quality, participatory planning, social cohesion, health and wellbeing and economics outcomes. Outcomes also include the lessons learnt, replication and scaling at a city and regional level, the implications for maintenance and future research.

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The total costs of the project were €2,219,227. This is based on the capital costs as incurred in specific years and ongoing operating costs (assuming constant annual costs over a 25-year period).

Improved hydrological performance The stormwater management system is designed to encourage on-site infiltration through the use of NbS by encouraging infiltration and attenuating water originating from hard surfaces. This includes adjacent highways and paved areas and swales were used to encourage the gradual conveyance of water and infiltration of the highway runoff. The raingardens provide stormwater attenuation and infiltration and a tree pit was deployed for the attenuation and reuse of stormwater via evapotranspiration. Previously highway gullies drained excess surface water into the sewer system.

The NbS features reduced runoff volumes between 87% and 100% on average with an average **volume reduction of 97.6% and an average peak flow reduction of 98.1%. The volume of water diverted from rainwater treatment amounts to 6,665 m^3 per year**.

Storm Christoph (In January 2021) brought a short period of intense rainfall to northern England. **West Gorton received 71mm of rainfall over a three day period, 87% of its average monthly rainfall. All water was retained by the swale during the event (i.e. no runoff via the outlet). All water had infiltrated within two days.**

The Park exceeds planning requirements. Where a development is being carried out on a previously developed site, i.e. a redeveloped or brownfield site, UK planning regulations requires the rate of surface water discharge has to be reduced by a minimum of 50% for the 1-in-1 year event. **The runoff rates from the NbS features meets both the CDA and brownfield standards as well as the stricter greenfield runoff rate.**

The Urban Heat Island (UHI) effect is when elevated hotter temperatures are felt in cities as compared to rural surroundings, particularly at night-time as the heat retained by artificial surfaces is released. **Ground temperature monitoring showed a fall in ground temperatures between baseline and intervention. Average ground temperature decreased by approximately 5°C, with a maximum temperature reduction of 24°C.** For the amenity turf areas in full sun replaced with wildflower turf, average temperature also fell by approximately 4°C, with a reduction in maximum temperature of approximately 5°C.

Biodiversity net gain has been a **success with a significanlty enchanced floral biodiversity**. There are approximatey 50 new species within the ground-level cover catergory, made up of a diverse mix of native wildflowers, grasses and ornamental plants. There are 13 new tree species, including flowering and fruiting trees.

Water quality has improved with the **swales and the raingarden reducing heavy metal concentrations.**

Social impacts were measured over 600 face to face “intercepts” and the use of the MOHAWk (Method for Observing Health And Wellbeing activities). **All stakeholders reported an increase in knowledge and expertise in NbS, at both individual and institutional level. Significantly, there was a positive impact on citizen learning with an increase in interest levels**. There is also evidence showing how **NbS can enhance the senses, imagination and thought processes. Local residents were reported to have increased their personal awareness of their local environment by 50%.**

Health and wellbeing measures improved and in 2021 there were an average of 350 daily park visitors either walking or undertaking vigorous activity:

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- the number of children and teenagers observed walking in the target outdoor space had increased from 126 in 2018 to 290 in 2021.
- the number of adults observed walking in the target outdoor space increased from 346 in 2018 to 542 in 2021.
- the percentage of adults interacting with each other in the outdoor space increased from 27.6% in 2018 to 42.3% in 2021.

Evidence from a comparison site also shows that the increase in the use of the space in West Gorton was almost twice as much as for the comparison area in the same period.

<u>**Positive Economic impact**</u> was measured using a Cost Benefit Analysis (CBA) to compare the overall benefits against costs looking at **three main areas: avoided costs of rainwater treatment, increases in residential property prices** and **physical health benefits.**

The **volume of water diverted from rainwater treatment amounts to 6,665 m^3 per.** Treatment costs are estimated at **EUR 0.150 / m^3**, based on 2012 data on surface water management in combined sewer systems.

The increase in residential property prices in the surrounding area is calculated by multiplying the number of properties within a 300 meters radius of the community park to the average residential property value, and the property price lift percentage to this value. **This gives a one-off increase in value through the surrounding properties of EUR 1.86 million.**

Avoided healthcare costs were calculated by multiplying a monetary estimate of the health care savings per marginal physically active visit to a green space. The value for **health care savings is EUR 3.85** (**GBP 3.36 per) marginal physically active visit to a green space.** This suggests an overall an economic value of avoided healthcare costs of **EUR 140,000** annually or **EUR 2 million** in present value terms (over 25 years).

By combining the avoided healthcare costs with the value to users of the personal health benefit from increased physical activity, there is an economic value of health benefits of EUR 3.8 million. Together this is an economic benefit cost ratio of 2.5.

<u>**Learning about NbS and SuDs has been a key element.**</u> The Park provides opportunities to inform future city developments and what was previously a featureless, flat landscape now has purpose-built installations with a need for a bespoke maintenance plan with inevitable maintenance overheads. **The lessons learnt include the need for specialist knowledge and skills.** The University has established a new MSc course in green infrastructure. The course is the only one in the UK 100% focused on green infrastructure and attracts students from around the world including China and Iraq as well as the UK.

<u>**The strategic impact of GrowGreen**</u> has had a clear impact in Manchester. NbS is now integrated into the city's Climate Change Action Plan. The project influenced the construction of Mayfield, a 6.5 acre park which opened in September 2022, the first new park in Manchester for over one hundred years.

<u>**Future research**</u> offers scope to look again at temperature dynamics and microclimates once the vegetation / trees of the community park are fully established. Research areas include wildlife development, the impact of contaminated runoff on soil condition and long-term heavy metal loading. There is also important work to be developed on the concept of blended neighbourhood models where residents, health care providers, local authorities and water companies all contribute to the investment in NbS.

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GrowGreen has been a unique opportunity for Manchester. For the future, NbS is about changing behaviour in city council departments and with other partners to recognise that NbS is part of the response to the challenges of urban environments. Alongside this is the positive impact on citizens and their appreciation of the value of green infrastructure.

To emphasise this point, the final remarks are best left a West Gorton resident: ***"It's brilliant. Because I was part of the group that helped design the park, it feels like it belongs to you. It's worth every penny!"***

For an introduction to the park, the people involved and the results of two years of monitoring, **take a look at the GrowGreen video @** www.youtube.com/watch?v=YNNlEi7hAiM

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2 Introduction

This report details the interventions and outcomes of the Manchester GrowGreen project, is a five-year Horizon 2020 research project, beginning in 2017, concluding in 2022 and funded as part of the European Commission's 2016 Smart Cities and Communities Call "Demonstrating Innovative Nature Based Solutions in Cities". The work was carried out alongside two other Demonstration Projects by GrowGreen Front Runner Cities: Valencia (ESP) and Wroclaw (PL) along with two replication cities, Brest (Fr), Modena (IT) and Zadar (HR). Together, they looked at the ways Nature Based Solutions (NbS), in particular Sustainable Urban Drainage Systems (SuDs), can help to adapt cityscapes to a changing climate.

The site area identified for the GrowGreen Project was in West Gorton, a city suburb in Manchester within the North West of England, UK (Figure 1). Located three kilometres to the south east of the city centre, West Gorton is a former heavy industrial area which has suffered from several decades of deindustrialisation and neglect, high levels of social deprivation, negative health indicators, poor quality housing, and an increased level of unemployment compared to local and national indicators.

The Demonstration Project site is on land managed by Manchester City Council (MCC) in an area undergoing significant regeneration, including new housing and improved infrastructure. The proposal to create a new space for public recreation provided an opportunity to develop NbS for the GrowGreen project and to evaluate how it can mitigate climate change, as well as supporting wider socio-economic benefits.

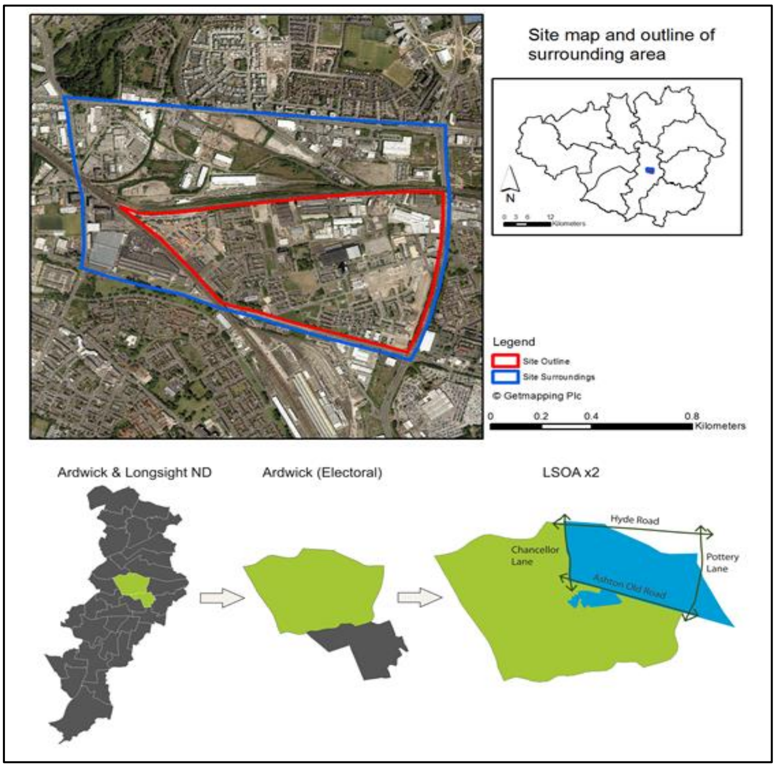

Figure 1 West Gorton location maps

The site originally consisted of an unattractive park area with outdated play equipment and an overgrown brownfield site as a consequence of housing demolition. Figure 2.

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Figure 2 West Gorton Green prior to redevelopment

The key objectives were to:

- Establish an evidence base that NbS in cities provides a cost-effective, sustainable, and replicable means of increasing urban water and climate resilience.
- Provide information on other co-benefits, including improvements in health and wellbeing, social cohesion, biodiversity, and socio-economic indicators.
- Create a 'Living Lab' to encourage investment and development of NbS in other parts of Manchester and neighbouring districts.
- Influence the city's green infrastructure strategy.

This report evaluates the extent to which these objectives have been achieved.

[A virtual tour of the park is available on YouTube.]

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3 Diagnostic Report

In May 2018, the University of Manchester (UNIMAN) produced a baseline diagnostic report structured on the Eklipse framework[1] (reference D1.1 Diagnosis and Baseline of Front Runner Cities).

3.1 Climate

Manchester has a temperate oceanic climate. Summers are usually mild, although temperatures often exceed 20 °C. Winters are cool. Climate data reveals that there has been a warming between 1961 and 2010. The annual maximum temperature has increased, on average by 0.7 °C. The number of frost days has decreased for the same period. The average Urban Heat Island Intensity (UHII) in West Gorton is increasing.

3.2 Precipitation

Rainfall is relatively evenly distributed throughout the year with total rainfall slighly less that the UK average. Changes in rainfall between the two 30-year periods of 1961–1990 and 1981–2010 show an enhanced seasonal variation, with an increase in winter/autumn precipitation and a decrease in summer precipitation.

3.3 Water Management

River network - there are two river catchments in Manchester: the Irwell and the Upper Mersey. Both flow into the Manchester Ship Canal, Figure 3. The Irwell covers northern and central Manchester and the Upper Mersey mainly south. The main rivers in the city are the Irwell, Irk, Medlock and Mersey. Many of the non-main (ordinary) rivers are culverted. The Irk, Medlock and Corn Brook pose the highest risk of flooding. Whilst there are no open watercourses in West Gorton, the culverted Corn Brook is subterranean.

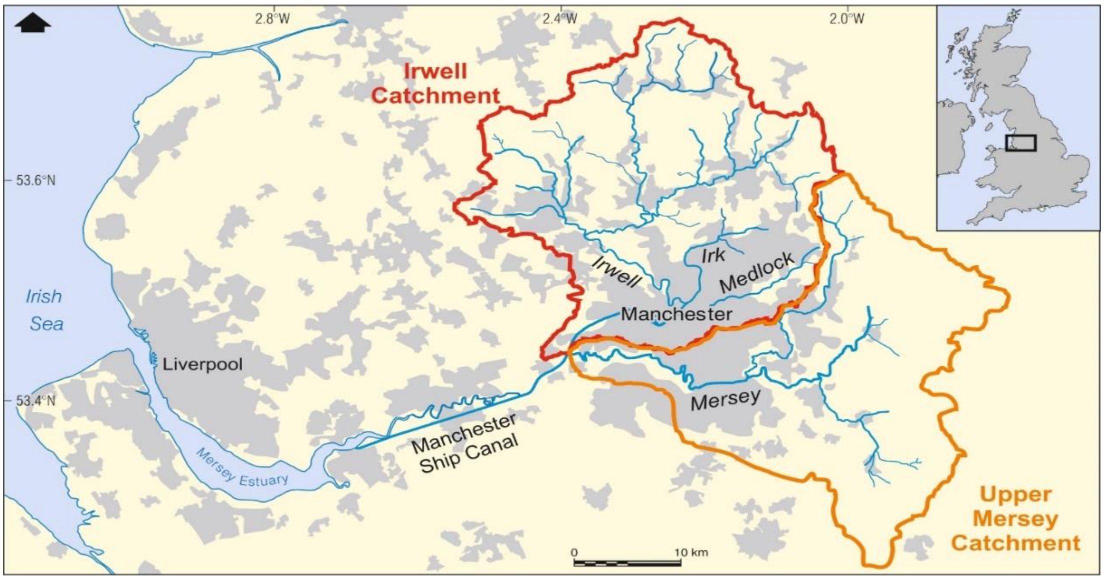

Figure 3 Manchester's river catchments

Drainage - West Gorton is served by a combined public sewer system operated by the regions privately owned water operator, United Utilities. Foul water for properties in the western half of the area is

[1] www.eklipse-mechanism.eu

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discharged to the main trunk sewer on the nearby main road (Hyde Road). The eastern half discharges via a combined sewer onto the main sewer on another major highway, Gorton Road. A Combined Sewer Overflow (CSO) is located on junction of Bennett Street and Vaughan Street. This is designed to discharge excess sewage to the Corn Brook culvert during heavy or prolonged rainfall, Figure 4.

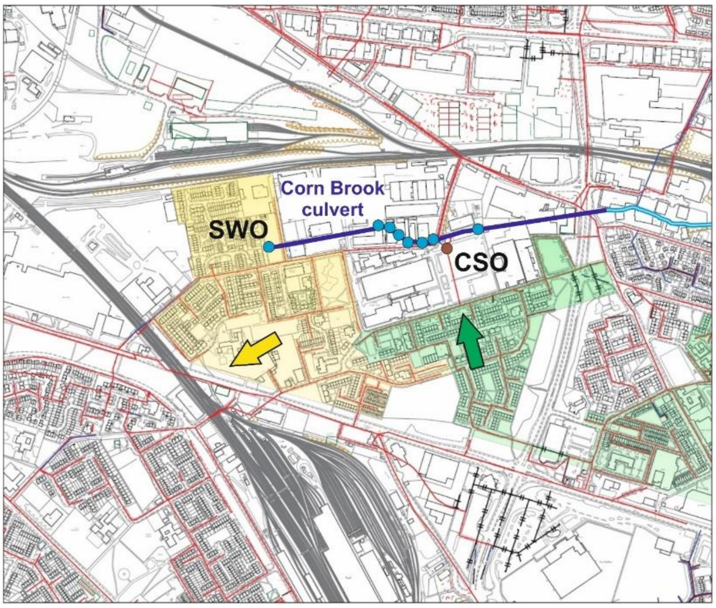

Figure 4 Sewer system in West Gorton.

Surface Water Outfalls (SWOs) are designed to discharge excess rainwater from roofs and streets to nearby watercourses. A number of SWOs are located on the culverted Corn Brook, the majority within an industrial estate. Existing properties within West Gorton discharge surface water to the CSO along with foul water. Surface water is discharged to the nearby Corn Brook rather than into the combined sewer system.

Flood Risks - there are both fluvial and pluvial flood risks:

- Fluvial (water course)- The Environment Agency has reported that there is no record of previous flooding in West Gorton. However, their flood map reveals a significant portion of West Gorton is at moderate to high risk of flooding from Corn Brook and Black Brook. Flood depths are predicted to be between <0.5 and 1m for a “1 in 100” year event and > 2m for a “1 in 1000” event. The area at greatest risk is the Bennett Street area and the container depot in a nearby railway viaduct, Figure 5.

- Pluvial (surface water) - There is significant susceptibility to surface water flooding within West Gorton. This is marked at the junction of Pottery Lane (A6010) and Gorton Lane. Bennett Street near the junction with Hyde Road is also susceptible, Figure 6.

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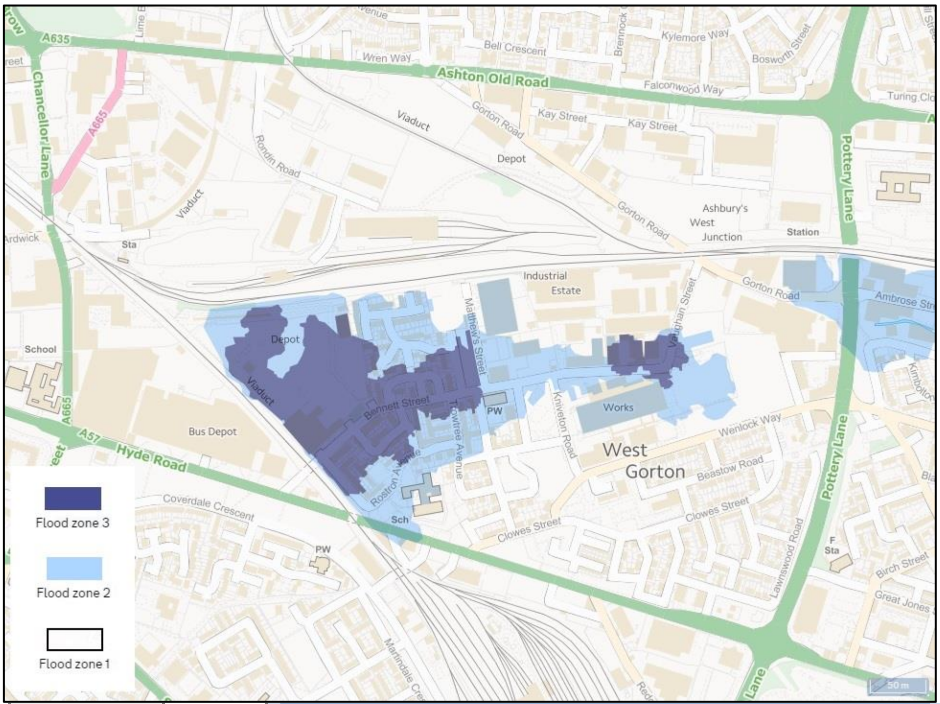

Low	**Zone 1**	**Land having a less than 1 in 1,000 annual probability of river flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)**
Medium	**Zone 2**	**Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding**
High	**Zone 3**	**Land having a 1 in 100 or greater annual probability of river flooding**

Figure 5 Flood risk from rivers. Source: Environment Agency Flood Map 2017

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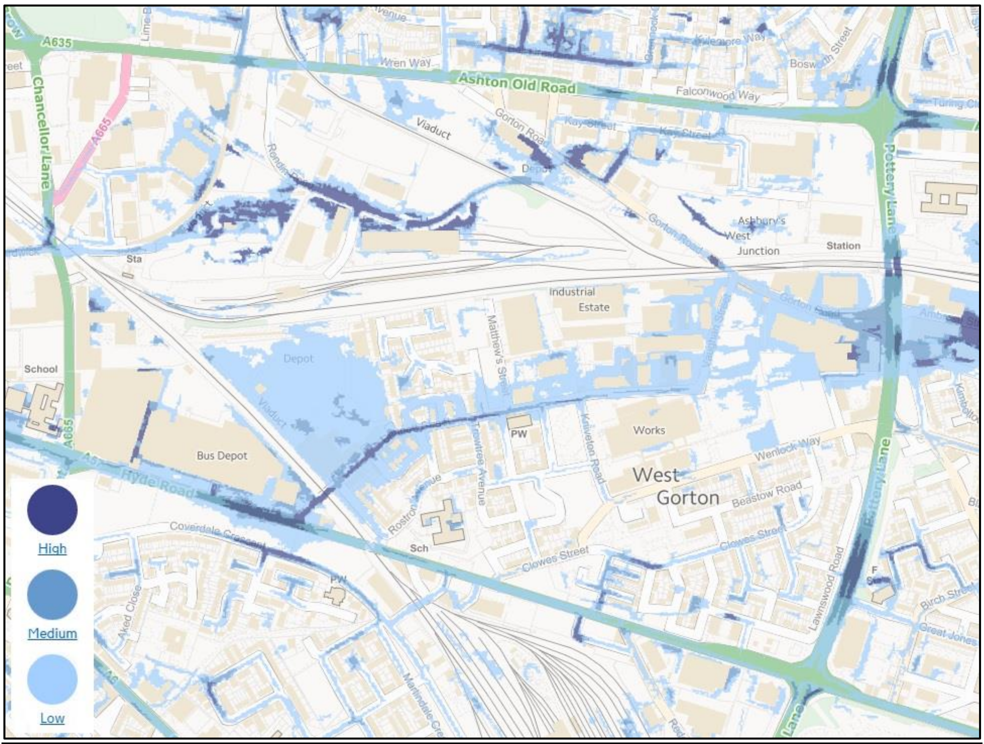

Low	**Each year this area has a chance of flooding between 0.1% and 1%**
Medium	**Each year this area has a chance of flooding between 1% and 3.3%**
High	**Each year this area has a chance of flooding greater than 3.3%**

Figure 6 Flood risk from surface water. Source: Environment Agency Flood Map 2017

3.4 Water Quality

The overall status for the Irwell/Manchester Ship Canal waterbody, of which the Corn Brook is a tributary, is classed as “Moderate”. The Environment Agency report the key reasons for not achieving “Good” status as:

a) intermittent sewage discharges
b) continuous sewage discharges
c) contaminated bed sediment within the waterbody
d) physical modification

A range of measures to address the first three issues are being undertaken in the Irwell/Manchester Ship Canal (Irk to confluence with Upper Mersey) waterbody. United Utilities have an ongoing investment programme, including a large-scale aeration system to maintain high levels of oxygen and additional treatment to reduce ammonia concentrations at the local sewage treatment works.

Given the small size of the Corn Brook relative to the overall size of the Irwell/Manchester Ship Canal and associated upstream catchment (circa 500 km^2), the relative impact of localised improvements in water quality within the Corn Brook are likely to be difficult to detect in the downstream main waterbody (Irwell/Manchester Ship Canal).

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3.5 Air Quality

West Gorton has significant traffic-derived air pollution as shown in Figure 7, Figure 8 and Figure 9.

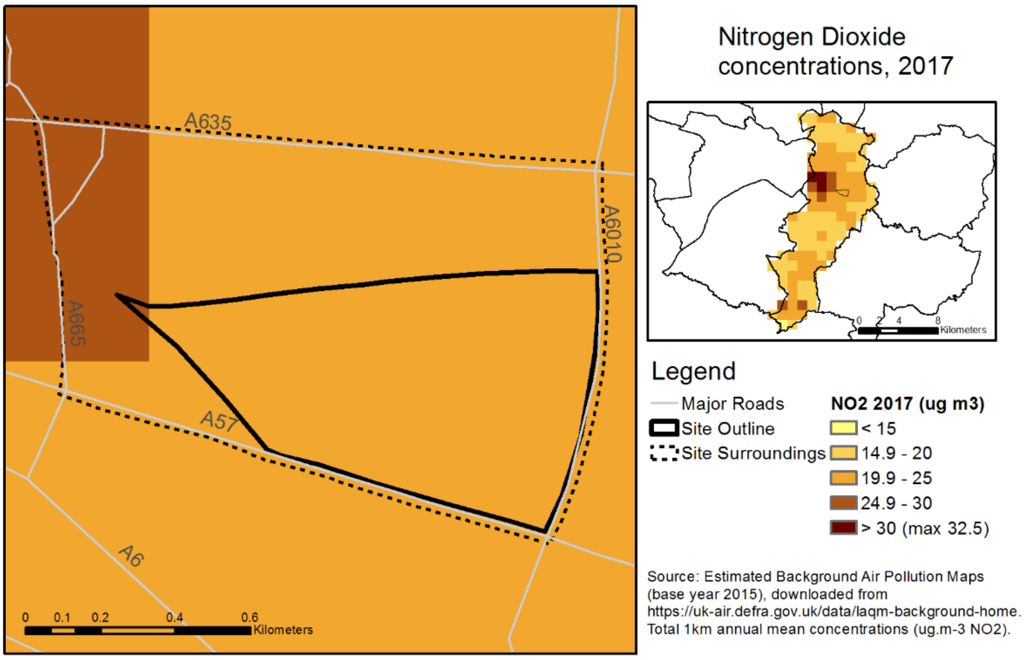

Figure 7 Estimated background concentrations of nitrogen dioxide West Gorton (base year 2015)

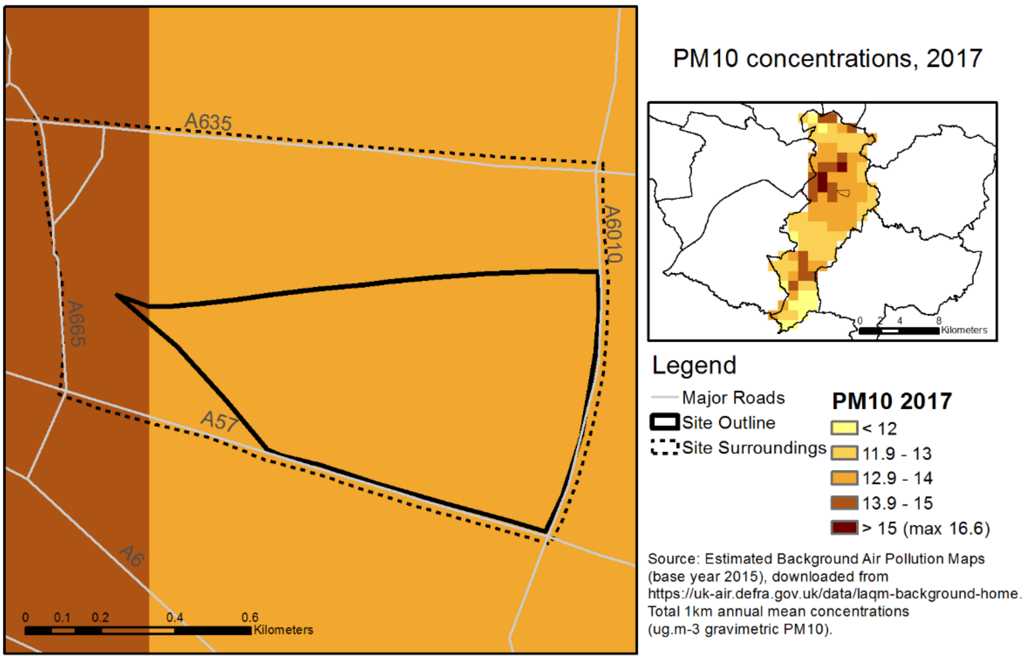

Figure 8 Estimated background concentrations of PM10 West Gorton (base year 2015)

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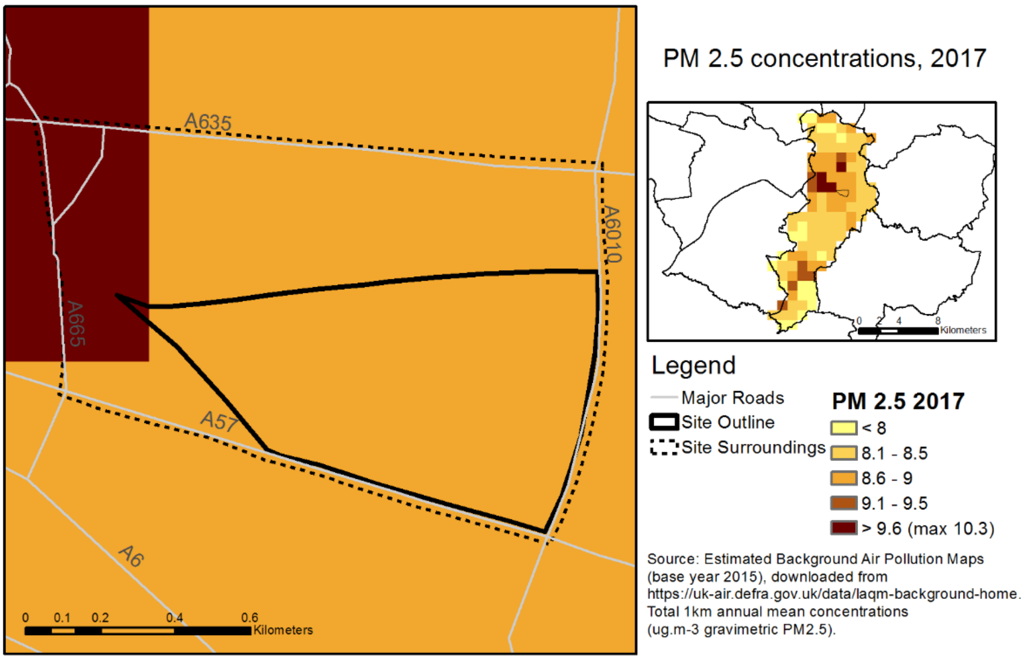

Figure 9 Estimated background concentrations of PM2.5 (base year 2015)

3.6 Noise

The site is subject to elevated noise from rail traffic as well as from roads, Figure 10 and Figure 11.

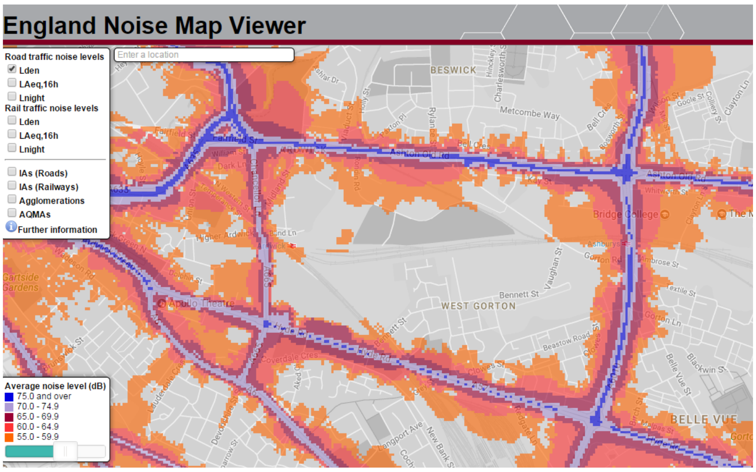

Figure 10 Noise from road traffic (day-evening-night) 24 hr annual average noise level (decibels) weighted evening & nights

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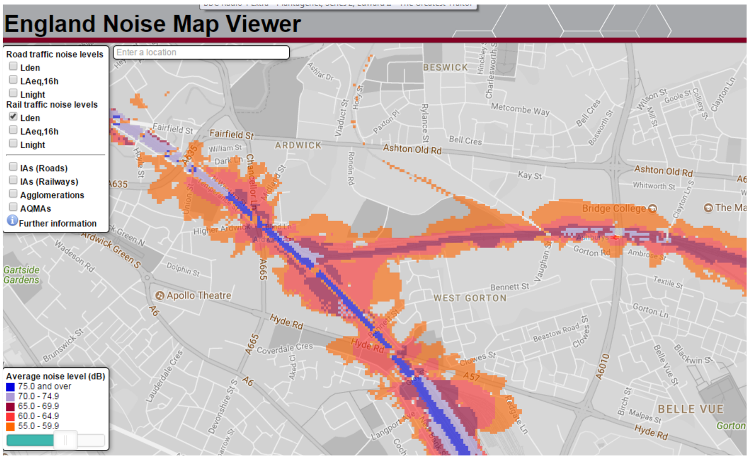

Figure 11 Noise from rail traffic (day-evening-night) 24 hr annual average noise level (decibels) weighted evening & nights

3.7 Greenspace

Greenspace in West Gorton makes up 22% of the area. This is significantly lower than 54% across Manchester. The area has suffered a net loss of approximately 10% of greenspace since 2000, primarily due to housing developments, Figure 12.

Figure 12 Greenspace provision within West Gorton. Aerial image shown is March 2017.

3.8 Soil Contamination

Previous site investigations revealed that reworked natural clay and dense sands are overlain by materials from previous developments etc. This ground is commensurate with historical heavy industry at the site and consists of:

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- Topsoil to depths of 0.6m
- Demolition waste between 0.4m and 3.1m
- Ash and clinker between 0.4m and 3.1m

Elevated levels of heavy metals and hydrocarbons were detected in the ash and clinker (from coal-fired boilers, furnaces, and other high-temperature combustion). Asbestos fibres were also detected in the demolition waste from one trial pit south of the existing playground.

3.9 Social, Health and Economic

Participatory planning and governance - regeneration in East Manchester has taken a partnership approach to planning and development. MCC has actively promoted the use of Neighbourhood Planning (NP) as a mechanism for collective and deliberative decision-making. This work has been supported by the promotion of resident steering groups.

Social cohesion - levels of crime in the area are relatively low. In September 2017, West Gorton was ranked 40th of 92 areas. This represents the 43rd percentile in the context of Manchester authority boundary giving it 1st in place in the "least crime" ranking.

Health and wellbeing –health data is not available at a West Gorton level. Neighbourhood data from the wider Ardwick and Longsight Neighbourhood Boundary Care profile report (July 2017)[2] shows that compared with the rest of England, the area is significantly worse for health outcomes in these areas:

- Proportion of lower birth weight deliveries
- Proportion of people with 'bad' or 'very bad' general health (2011 Census)
- Proportion of pensioners living alone (2011 Census)
- Proportion of obese children and children with excess weight in Reception Year and Year 6
- Rate of emergency hospital admissions in 0–4-year olds
- Rate of hospital admissions for injuries in 0–4-year olds; 0-15 year olds
- Rate of emergency hospital admissions for all causes; coronary heart disease; stroke; COPD
- Rate of hospital stays for alcohol related harm
- Mortality rate (all ages) for all causes; all cancer; all circulatory disease; coronary heart disease; stroke; respiratory diseases
- Premature mortality rate (under 75) for all causes
- All cancer; all circulatory disease; coronary heart disease

Vulnerability to Climate Change **-** there are higher numbers of children under 5 and higher proportions of people in ill health compared to the English average in the area. These groups often show an inability to respond to and recover from heat-related events and have an acute inability to prepare for them. As a result, compared to the average for England, people living in West Gorton may be particularly vulnerable to climate-related events.

Economic - West Gorton is within the top 1% of areas within the UK for income deprivation, and in the top 5% in terms of employment deprivation. Ward level data shows the immediate local areas are within the top 1% of areas within the UK with regard to income deprivation, and within the top 5% in terms of employment deprivation (MCC, 2015[3]). Approximately 37% of local residents are in full time

[2] www.manchester.gov.uk/downloads/download/6523/neighbourhood_profile_-_ardwick_and_longsight
[3] https://www.manchester.gov.uk/downloads/download/4220/public_intelligence_population_publications

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employment and the unemployment rate was 22%, compared to 12% for Manchester and 7.6% for the UK. Lower Super Output Area (LSOA) data offers a greater level of fine-grained insight for some indicators and shows that 37% of local people are categorised as working in low-income occupations, compared to 26% in the UK, a 11% difference.

4 Determining Co-Benefits

Whilst the driver for the project was to improve climate and water resilience, the diagnostic report demonstrated that there were a number of co-benefits that could be achieved. In December 2018 a workshop was held with the key co-design stakeholders. The aim was to agree the co-benefits to shape and guide the co-design process. Table 1 lists the participants.

Name	Organisation	Role in project	Stakeholder role
Michelle Oddy	Manchester City Council	Project Coordinator – GrowGreen	Integration into smart city platform
Kat Betsou	Manchester City Council	Project Officer – West Gorton Project	Local policy/politics
Dave Boothroyd	Manchester City Council	Capital Programme Manager - Leisure Services	On-going maintenance
Andrea Broodbank	Manchester City Council	Project Manager - West Gorton Project	Local policy/politics
Adam Barker	University of Manchester	Monitoring and evaluation	Robustness of research-impact
James Rothwell	University of Manchester	Monitoring and evaluation	Measurability/ kit/sensors
Ian Kershaw	Guinness Partnership	Social landlord, West Gorton	Community views
Julie Hyslop	Groundwork	Citizen engagement	Community views
Jenny Ferguson	BDP architects	Landscape architect	Design viability
Andrew Jackson	Arup	Engineer (water)	Design viability

Table 1 West Gorton KPI workshop participants

Figure 13 KPI workshop

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The process was led by Professor James Rothwell (UNIMAN). Measurement methodologies were agreed for each main benefit, with the selected co-benefits and agreed Key Performance Indicators (KPIs) as developed by Tecnalia (Working with WP2 Monitoring and Evaluation framework,- D2.1) based on the Eklipse framework. A consultation process with local residents also identified two additional indicators: air pollution and traffic speed.

Participants were asked to score each key challenge for importance and relevance to the project through the lens of their interests. The scoring was 1 - "little importance/relevance" to 5 "very important/relevant". Scores were totalled in order to determine a ranking for each co-benefit. The results are shown in Table 2.

Discussions developed a consensus on which of the co-benefits would be measured and supplement the climate and water resilience objectives.

	Impact/– benefit - science	**Impact/– benefit – policy politics**	**Community views**	**Practicalities – kit, sensors etc.**	**Practicalities - design**	**Practicalities - maintenance**	**Smart city compliance**	**Total Score**	**Ranking**
From Eklipse Framework									
Carbon storage	2	2	2	1	2	1	3	13	10
Distribution & access to green space	5	4	4	5	5	5	3	31	3
Biodiversity	4	4	5	4	5	5	3	30	4
Water quality	1	2	1	2	4	1	5	16	7
Air quality	1	4	4	1	2	2	5	19	6
Noise	1	3	2	1	2	1	5	15	8
Social, health & well being	5	5	5	5	5	5	3	33	2
Economic Impacts	3	3	3	3	2	1	4	19	6
Locally identified priorities									
Smell (local waste depot)	1	2	5	1	3	1	1	14	9

Table 2 Co-benefit priortisiation

A number of co-benefits were eliminated from the design process for the following reasons:

- Carbon storage - tree planting would have to be at a large scale to obtain a discernible impact of carbon removal/storage from the existing greenspace already present.
- Water quality - the only water course in West Gorton is culverted (underground) and has a large catchment area. It would not be possible to detect its impact.

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- Air quality - the site is bounded by two major roads into the city centre and two railway lines. The workshop agreed that improvements in air quality could not be achieved without wider policy commitment to significantly reduce traffic. There were no plans to undertake this for the duration of the GrowGreen project.
- Noise - the same arguments as air quality apply and it was agreed that the noise from transport could not be mitigated by the interventions.
- Odour – one of the main complaints from residents was the smell from a household waste treatment facility adjacent to the demonstration area. Again, the workshop was agreed that this could not be addressed within the constraints of the project.
- Economic indicators - it was agreed that wherever possible the project would contribute to this KPI. For example, the number of FTE working on the demonstration project, NbS products used, etc., but that this could not be a key design driver.

The agreed co-benefits were:

- Improved social connections, health, and well-being, including social cohesion and stakeholder engagement.
- Improved access to green space and the distribution of public green space.
- Biodiversity via the enhancement of species present, habitat and vegetation.

Challenge Area	West Gorton KPIs
1. Climate Mitigation & Adaptation	• Humidity. • Air temperature. • Ground temperature. • Surface temperature.
2. Water Resilience	• Run-off coefficient in relation to precipitation quantities.
3. Water Management	• Reduction on runoff peak discharges. • Reduction on runoff volume rates.
4. Green Space Management	• Diversity of trees and shrubs. • Diversity of vegetation strata. • Green area per capita. • Structural connectivity. • Accessibility to greenspace. • Percentage of individuals with access to at least 2 ha of green space within 300 m of home, • Percentage of individuals with access to at least one 20 ha site within 5 km of home, • Number of nature reserve/conservation areas per 1000 population
5. Air Quality	• Out of scope
6. Noise	• Out of scope
7. Participatory Planning and Governance	• Number of meetings held with citizens to explain the progress of the project. • Number of persons (on average) involved in the activities carried out under the project. • Percentage of women (on average) involved in project activities. • Percentage of older/younger people (on average) involved in project activities. • Percentage of ethnic minorities (on average) involved in project activities. • Number of civil society entities representing community members. • Number of civil society entities that have participated in the execution of the project in relation to the total of entities with presence in the neighbourhood. • Number of initiatives proposed and implemented by the public in the framework of the project. • Degree to which population has faith in decision-makers.

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	• Degree to which population has positively changed his/her opinion of decision makers. • Degree to which population believes in the value of procedures. • Degree to which the population believes that their participation in the project has served something. • Degrees of interest in urban ecosystems. • Extent of understanding of attributes and functions. • Degree to which interest and understanding has changed over time. • Degree to which community attach significant value to nature-based solutions, rankings of preferred nature-based types. • Degree to which policies and plans have changed to incorporate nature-based solutions. • Degree to which organisations have enhanced their knowledge and understanding of nature-based solutions.
8. Social Justice and Social Cohesion	• Percentage of households in full-time employment, percentage of households earning less than the national and regional average, percentage of households classified as deprived. • Percentage of people who feel safe in their neighbourhood • Number of people using green space. • Percentage of people taking notice of their environment. • Percentage of people who feel integrated into their local community • Percentage of people interacting with each other in an outdoor space. • Percentage of people with an attachment/sense of belonging to the neighbourhood. • Percentage of people of who feel able to trust one another within the neighbourhood.
9. Public Health and Wellbeing	• Percentage of people who are happy in their daily lives. • Percentage of people undertaking forms of physical activity. • Percentage variation in activity levels by age-group, gender, and ethnicity. • Percentage variation in levels of activity.
10. Potential of Economic Opportunities, Green Jobs and Business Models	• One-off construction costs. • Recurring / maintenance costs. • Property betterment. • Direct jobs & local economy. • Indirect jobs & local economy. • Avoided cost of run-off treatment.

Figure 14 West Gorton KPIs linked to Eklipse challenges

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5 Designing for Key Indicator Impacts

5.1 Design Overview

The design has three interconnected areas, each with distinctive elements and NbS features in Park A, Park B and Park C (Figure 15).

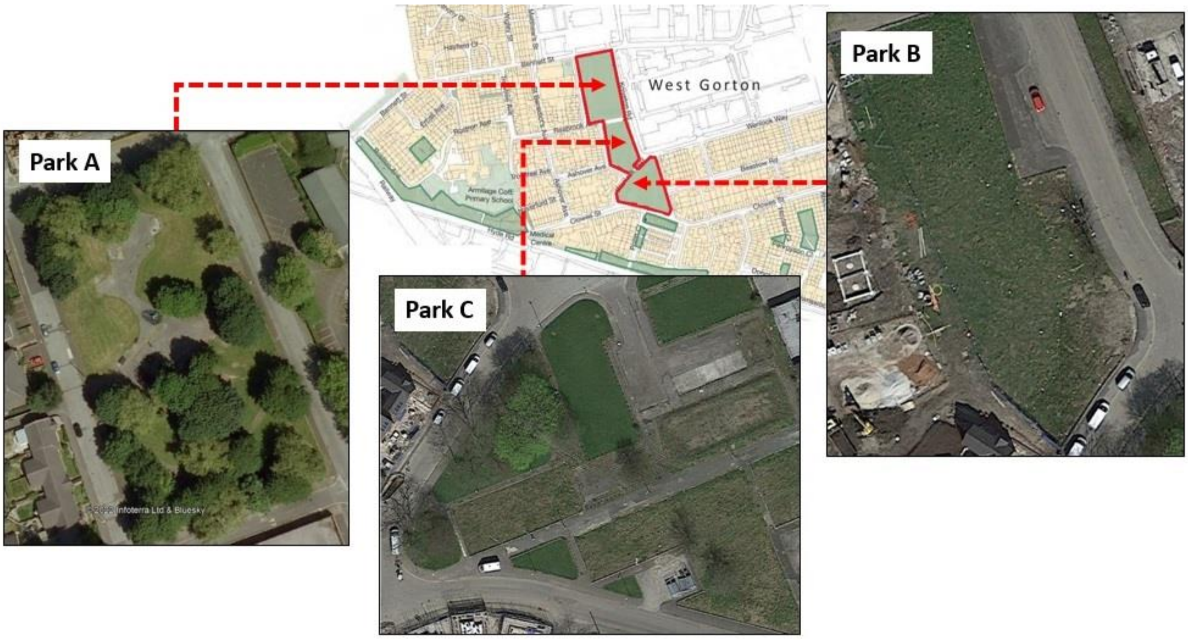

Figure 15 Location of the West Gorton Community Park (red line boundary), together with aerial photographs prior to construction (Source: Google Earth).

- **Woodland area** – Park A (north) a planted swale, a bio-retention tree pit, a picnic/seating area, an informal play area with climbing wall, timber play features, and a basketball court.
- **Meadow area** – Park B (central) meadow planting, orchard trees, picnic tables, edible hedgerows, exploration play and contact with nature through mounds and a stepping-stone trail. This zone also includes a planted raingarden and a series of long linear swales.
- **Community Plaza Garden** – Park C (south) sensory planting, flexible event space, community growing spaces and seating. This area includes permeable paving, a raingarden with bio-retention tree pit, and a planted swale.

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Figure 16 Landscape plan showing the three áreas (from the top – Park A, B, C)

Figure 17 Woodland area (Park A)

Figure 18 Meadow area (Park B)

Figure 19 Community Plaza area (Park C)

5.2 Water Resilience and Management

An important design driver was to reduce the risk of surface water flooding using a range of SuDs. The design was based on the concept of a “park that drinks water” partly inspired by a visit to Wuhan (Nov 2018). The drainage design is shown in Figure 20.

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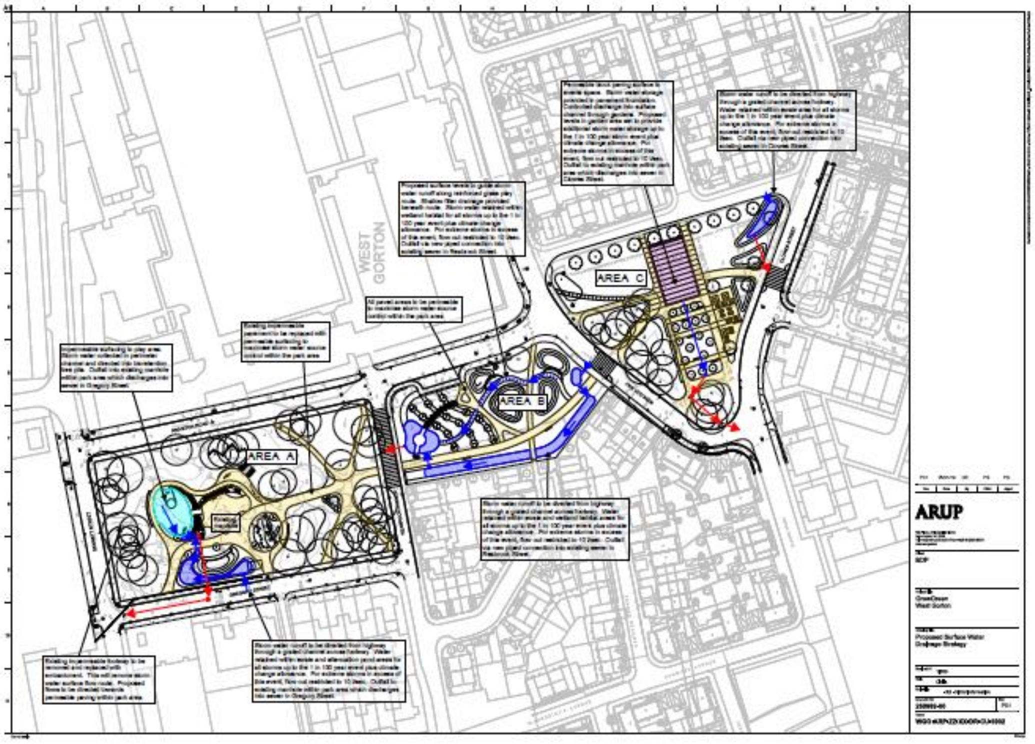

Figure 20 Park drainage design

Woodland – features include several NbS elements, a planted swale, a bio-retention tree-pit and permeable surfacing. The planted swale takes rainfall-runoff from the adjacent road via a specialist drainage gully unit. This water would normally be directed straight into the sewer system with associated capacity issues and flooding risks. The basketball court has an impermeable surfacing which directs rainwater toward a bio-retention tree pit with two feature trees. A sand filled carpet was chosen for beneath the play area with a compacted gravel surface to the sides of the planting. There is also a permeable tarmac path. Any excess water not used by vegetation in the swale or the bio-retention tree pit is returned to the sewer via an outlet. UNIMAN monitored stormwater runoff via the inlets and outlets of the NbS features enabling the evaluation of the effectiveness of the Park to 'drink water'.

Figure 21 Woodland - drainage features

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Meadow – this features the longest swale sequence in the Park, running the entire length of the meadow area. As in the woodland area, water is taken from the adjacent highway and redirected into the swale where the water is encouraged to infiltrate into the underlying soils. A raingarden (a sunken planted basin with decorative decking) is connected to the swale at the lowest point. This is designed to take any water that is not used by the swale. Finally, any excess water is returned to the sewer via an overflow outlet. Runoff monitoring is as above.

Figure 22 Meadow - long swale

Community Plaza - the main NbS feature in this area is the large plaza area and associated sunken rain garden. The plaza is constructed of permeable paving, allowing rainfall to infiltrate into the sub-base. The sub-base is lined with an impermeable membrane enabling rainwater to be stored and redirected towards the long rill, irrigating trees and plants, terminating in a bioretention tree pit. Any water not utilised by trees or plants is directed via an outlet linked to the main sewer. A swale collects water from the adjacent highway. Stormwater runoff is also monitored here.

Figure 23 Community plaza - permeable plaza and rill

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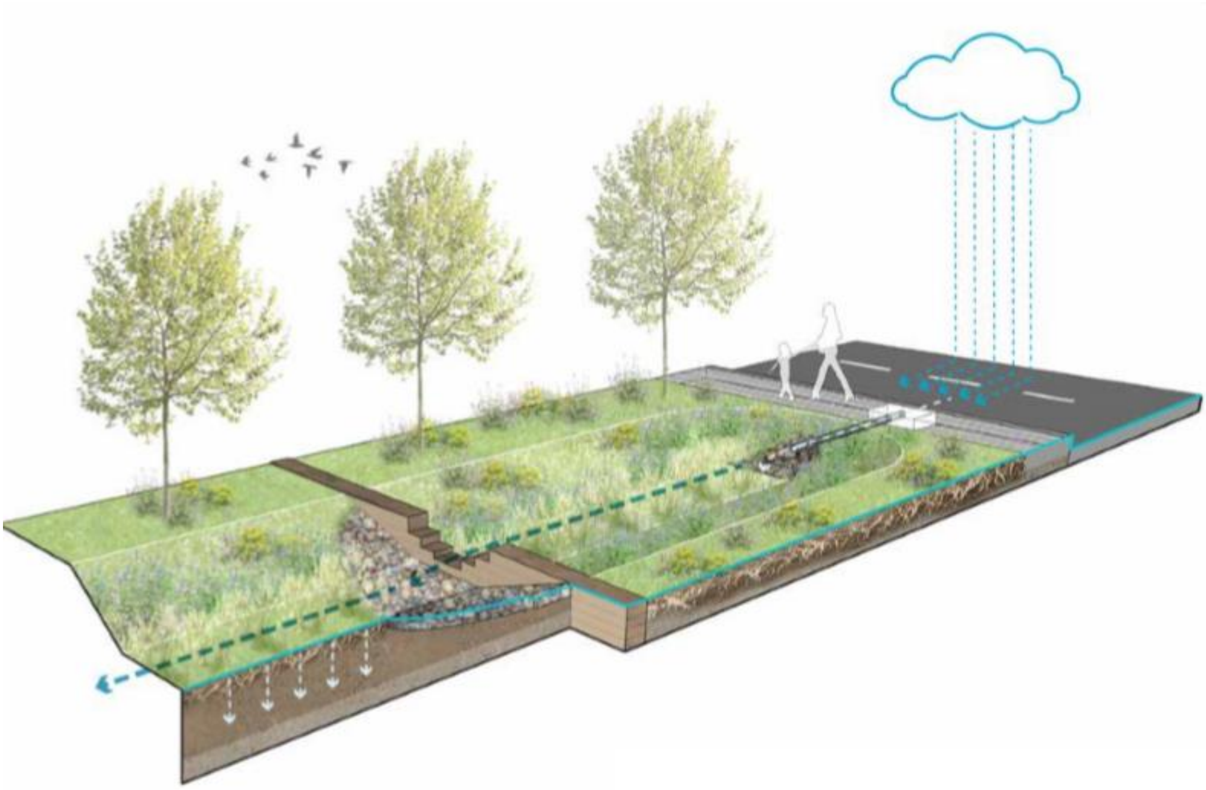

Figure 24 Extract from the park information board with details about wáter management

5.3 Land Surfacing and Footpaths

Prior to redevelopment the previous park was characterised by large areas of tarmac/asphalt, black rubberised surfaces below play equipment and bare soils. Dark surfaces absorb and release heat, contributing to increases in air temperatures. The new park was constructed using lighter surface materials, including light green sand-filled carpets below play equipment, lightly coloured tarmac and golden gravel paths, all designed to reflect solar energy.

5.4 Biodiversity

Native species trees, shrubs, perennials, and grasses were planted to enhance the woodland feel and to encourage insects, birds, and small mammals to forage. Existing trees were retained where possible with new trees of native, ornamental, and fruiting varieties, in addition to new shrub and perennial planting. To extend the flowering season to encourage pollinators, bulb planting provides sources of nectar at times of the year when food sources can be scarce. Areas of wildflower meadow and grassland are left to grow long in order to support and encourage native birds, mammals, butterflies, bees and other insects and invertebrate species. Landscape maintenance will play a key role in the ongoing success of the implemented planting strategy. A list of the planting for the three park areas is given in Appendices

Appendix I - Planting Schemes.

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Figure 25 Formal planting in the community plaza

5.5 Participatory Planning and Governance

The Project drew on the principals of participatory planning, developing the design in consultation with stakeholders from a diverse range of organisations. These include local citizens, politicians, schools, private companies, an environmental charity, a housing association, academics, and a range of MCC services.

It was recognised that engagement with the local community would be key to the ongoing success of the park and this was a great opportunity to engage citizens around the concept of NbS and climate change. The social housing provider and core partner (Guinness Partnership Ltd -TGPL) worked with Groundwork, an environmental charity, to deliver the community consultation.

The first stage of this process was awareness-raising, the perceptions of nature and the aspirations for new green space. This included visiting all 612 of the properties in the immediate area of the park; youth club sessions; consultation boards outside the local health centre and primary school and events. In this area Groundwork and the landscape designer developed appropriate plans. Residents gave feedback they wanted on more community growing spaces, spaces for sports, areas to gather, children's play areas and attractive areas with plants and flowers. Access for people with disabilities was also as important. Community engagement events were held at different local locations to get feedback on the designs.

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Figure 26 Consultation activity

Groundwork was contracted to establish a ‘Friends of West Gorton Park’ Group and arrange associated community events. The aim was to engage the community in a wide range of nature-based activities to teach them about climate change, biodiversity and the nature based solutions which feature in the park. From July 2021 until the end of May 2022, 32 events were hosted by Groundwork at the park. Highlights include winter wellbeing sessions, Easter and Christmas fun days and a community “BioBlitz”. By hosting a range of events for all age groups, knowledge levels and abilities, Groundwork has been able to reach a wide variety of people in the community. Engagement numbers have varied from 150 participants at one event to 0 participants on 2 occasions. There is a core group of around 30 people who regularly participate and a group of 4 who are committed to forming a Friends of the Park group.

Establishing local community groups can be challenging and more so in an area of socio-economic deprivation with the complexities of personal lives and historical challenges within communities. There was a divide in the community due to historical socio-economic issues and this still persists. This relates to the new estate built towards the east of the park. The new houses are larger and more expensive. Some of them are owned by the housing provider, Guinness, and some are privately owned. West of the park many of the homes are of older, smaller terraced housing. Some of the residents from the new estate have blamed residents from the other side for crime and anti-social behaviour.

Going forward, Groundwork have secured monies from the UK Lottery Fund to provide support for a further 18 months with the park forming part of their Green Community Hubs network, physical spaces that local communities have the responsibility for managing. There will also be ongoing input from the Council’s Neighbourhood Team.

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5.6 Social Cohesion

The designs showed how the park areas could work spatially and how it could connect with desire lines and paths across the site. It was felt it was important to connect both the old and the new communities: to the east is older housing with an existing community, and to the west are newly developed homes. Groundwork engaged with both sets of residents to ensure participation and engagement and to facilitate new relationships.

5.7 Public Health and Wellbeing

There are design features in all of the three park sections that seek to encourage exercise, relaxation, and social interaction. In the woodland there are play structures for younger children to play e.g., slides, swings, a small climbing wall (facing an indoor climbing centre) and a basketball court.

The atmosphere of the meadow encourages people to sit and relax, aiming to support visitors in their appreciation of nature by offering a quieter, more secluded zone. Here there is an area which offers space to think, relax, contemplate, and connect with nature.

In the plaza garden, an area was created to support community vegetable and herb growing, encouraging local groups to develop growing activities and an opportunity to learn from each other, e.g., exchanging gardening knowledge. There is also the potential to share proceeds of the vegetable growing with the wider community, sharing herbs or with a community picnic. There is also a surfaced area allowing for local community events.

6 Evidence Based Outcomes

The monitoring was undertaken by the University of Manchester. It was carried out in two stages:

- Pre-greening monitoring – performed prior to the interventions (2018 and 2019)
- Post-greening monitoring – performed a minimum of 2 years following the intervention (2020 to 2022).

This section provides a precise of the datasets, along with analysis of the Challenges determined by the co-benefits process in Figure 14. A detailed analysis can be found in the following:

- D2.2 Monitoring and Evaluation of Climate and Water Resilience.
- D2.3 Monitoring and Evaluation of Environmental Objectives.
- D2.4 Monitoring and Evaluation of Social Benefits and Participatory Planning.
- D2.5 Monitoring and Evaluation of Economic Objectives.

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6.1 Climate and Water Resilience (Challenge 1 and 3)

See D2.2 Monitoring and Evaluation of Climate and Water Resilience.

The Park incorporates NbS and SuDs to manage local stormwater runoff. They have been designed to manage urban runoff by encouraging infiltration and attenuating water originating from hard surfaces, including adjacent highways and paved areas. Within the Park, three NbS typologies have been deployed in the context of water management.

The ***stormwater management system*** is designed to encourage on-site infiltration. ***Swales*** encourage the gradual conveyance of water and infiltration of highway runoff. ***Raingardens*** have been used to provide stormwater attenuation and infiltration, with a tree pit deployed for the attenuation and reuse of stormwater via evapotranspiration. Prior to the creation of the new Park, all excess surface water drained to the local sewer system via highway gullies. Piped outlets of the swales, raingardens and tree pit are connected to this local sewer network and designed to only operate in the most extreme storm conditions where diffuse infiltration does not occur and storage capacity is exceeded. The NbS features deployed have been designed to detain all storm water up to a 1 in 100 year event, plus an additional 20% increased allowance for climate change. Drainage features have been constructed within three areas.

Figure 27 to Figure 29 show the construction and evolution of the NbS features.

Figure 27 Park A Swale; Jun 2020 (a), Jul 2020 (b), Jul 2022 (c), Jan 2020 (d), Jul 2020 (e), and Jul 2022 (f). Photo credits: Professor James Rothwell

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Figure 28 Park B Swale; Jan 2020 (a), Jun 2020 (b), Jul 2022 (c), Jan 2020 (d), May 2020 (e), and Jul 2022 (f). Photo credits: Professor James Rothwell

Figure 29 Park C Raingarden; Jan 2020 (a), Feb 2020 (b), Jun 2022 (c), Swale; Jun 2020 (d), Jul 2020 (e) and Jul (2022). Photo credits: Professor James Rothwell

6.1.1 Impact-Baseline vs Intervention

The overarching principle of the monitoring approach in the context of investigating water quantity was measuring runoff entering the 'inlets' and leaving the 'outlets' of each of the NbS feature. Monitoring chambers are located at both inlets and outlets, totalling 11 locations across Parks A, B and C.

Hydrological monitoring was conducted for over two years. An extensive set of rainfall-runoff events were captured. An overview of events captured is shown in Figure 30.

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Figure 30 NbS features in the West Gorton Community Park, with hydrological events captured. Photo credits: Professor James Rothwell

The run off characteristics were recorded for a number of storm events over the 2 year period.

	Park A		Park B		Park C	
	Swale	**Tree Pit**	**Swale**	**Raingarden**	**Swale**	**Raingarden**
Events	32	4	71	71	32	33
Average	98.7	100	99.9	98.6	100	88.3
Min	85.9	100	99.6	0	100	0
Max	100	100	100	100	100	100
Event = 100%	23	4	68	70	32	15

Table 3. Summary results – runoff coefficient

	Park A		Park B		Park C	
	Swale	**Tree Pit**	**Swale**	**Raingarden**	**Swale**	**Raingarden**
Events	32	4	71	71	32	33
Average	98.7	100	99.9	98.6	100	90.0
Min	81.0	100	99.5	0	100	0
Max	100	100	100	100	100	100
Event = 100%	23	3	68	70	32	15

Table 4 Summary results -volumetric reduction

	Park A		Park B		Park C	
	Swale	**Tree Pit**	**Swale**	**Raingarden**	**Swale**	**Raingarden**
Events	32	4	71	71	32	33
Average	0.002	0	0	0.01	0	0.07
Min	0	0	0	0	0	0
Max	0.04	0	0	1	0	0.65

Table 5 Summary results-peak flow reduction

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The NbS features reduce runoff volumes between 87% and 100% on average. There are big reductions in peak flow also. The swales are very effective in retaining runoff, with between 99-100% volumetric reduction on average. Although the tree pit retained all runoff from the basketball court, this is only based on 4 events. The raingardens exhibited the largest variation in hydrological performance. There was no runoff leaving Park B raingarden for 70 of the 71 events rainfall. Although Park C raingarden was effective in reducing runoff, this NbS feature reduced volumes by 87% on average, and therefore represented the NbS feature with the lowest performance of those investigated.

6.1.2 Storm Christoph

Storm Christoph brought some intense rainfall to northern England from 18 - 20 January 2021 (Figure 31). Over 150 mm of rain fell across some parts of Greater Manchester and for NW England this was one of the wettest 3 days on record. For some areas, over 200% of the monthly average rainfall fell during the storm (Met Office, 2021).

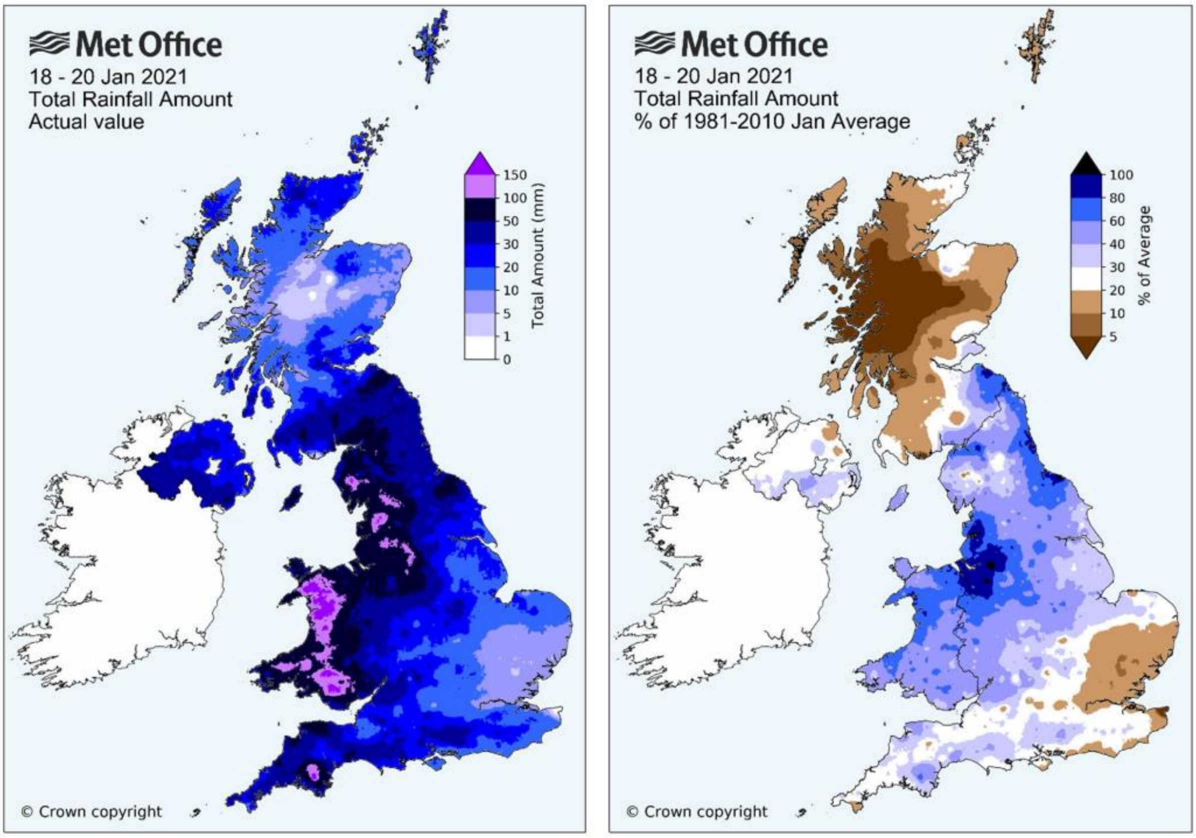

Figure 31. Total rainfall values for Storm Christoph – Jan 2021. Source: Met Office; 2021)

West Gorton received 71mm of rainfall over this three day period. Although this was lower than elsewhere in Manchester, it still represented 87% of the average monthly rainfall. The following photos in Figure 32 show the performance of the swale in Park A, during the peak of the storm on the 20 January. Repeat photos were captured 2 days later. **All water was retained by the swale during the event (i.e. no runoff via the outlet), with the timber check dam operating as intended (Figure 32). All water had infiltrated within two days.**

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Figure 32. Park A Swale during Storm Christoph (20 Jan 2021) and after the event (22 Jan 2021). Photo credit: Professor James Rothwell

The NbS features have been shown to be very effective in reducing runoff. They have performed as initially intended, demonstrating successful design and construction. Runoff from the Park via NbS features has been eliminated for a large proportion of the events captured, even for large storm events. Where runoff has been generated, this is negligible in many cases.

6.1.3 Meeting Planning Requirements

UK planning requires that where a development is being carried out on a previously developed site – i.e. a redeveloped site, or a brownfield site, the rate of surface water discharge must be reduced by a minimum of 50% for the 1-in-1 year event. The runoff rate for this return period estimated for the pre-NbS deployment in was 16.7 l/s, 7.7 l/s and 11.9 l/s for Parks A, B and C, respectively (generated as part of the planning application for the Park). **Where runoff was generated from the NbS features during the 2-year monitoring period (i.e. where total infiltration was not achieved), the *maximum* runoff rate recorded was only 0.99 l/s (at the Raingarden in Park C).**

The Strategic Flood Risk Assessment for Manchester (2010) denotes that a site being within the "Conurbation Core" as a Critical Drainage Area (CDA). This states that the recommended allowable discharge rates for CDAs following development should aim to reduce proposed surface water runoff rates to 50% of the pre-developed flows. **The runoff rates from the NbS features in West Gorton meet both the CDA and brownfield standards.**

Where a new development is planned for previously underdeveloped land, a local lead flood authority will request that the site be restricted to the 'greenfield runoff rate'. This is the runoff before any construction work begins on a new development in a 'green field'. It is dependent on rainfall and various ground properties, but is low, typically around 2 - 7 l/s. **Therefore, the Park's NbS features meet the stricter greenfield runoff rate which is applied to undeveloped land.**

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6.1.4 Heat Stress

The Urban Heat Island (UHI) effect is a phenomenon describing the elevated temperatures felt in towns and cities compared to rural surroundings. It is particularly felt at night-time as the heat retained by artificial surfaces is slowly released, keeping temperatures higher. This combines with other impacts such as the reduced cooling effect of vegetation in urban areas, and the compounding effect of anthropogenic heat.

The aim of this challenge was to quantify the benefits of NbS in the reducing heat stress and the UHI effect. Real time measurements of temperature, relative humidity and wind speed were monitored with additional data on temperature in control locations adjacent to the Park. The NbS thermal regimes under different climate change scenarios was estimated using numerical modelling (e.g. ENVI-MET[4]).

Ground temperature monitoring was also undertaken. Ground temperature was captured for the baseline period (2/7/2018 – 31/8/2019) and for 2 years post-construction of the NbS demo (16/7/2020-6/6/2022). I-button DS1922L-F5 thermochron (high capacity) loggers were deployed at five cm depth in a range of ground and exposure conditions. These included paved and grassed areas, located in full sun and shade conditions. A total of 24 loggers were programmed to capture data at hourly intervals.

The whisker plots are shown in Figures 33-36. These plots show the minimum, maximum and median (middle line) ground temperature, together with the interquartile range. **These plots show striking differences between ground conditions and exposure contexts.**

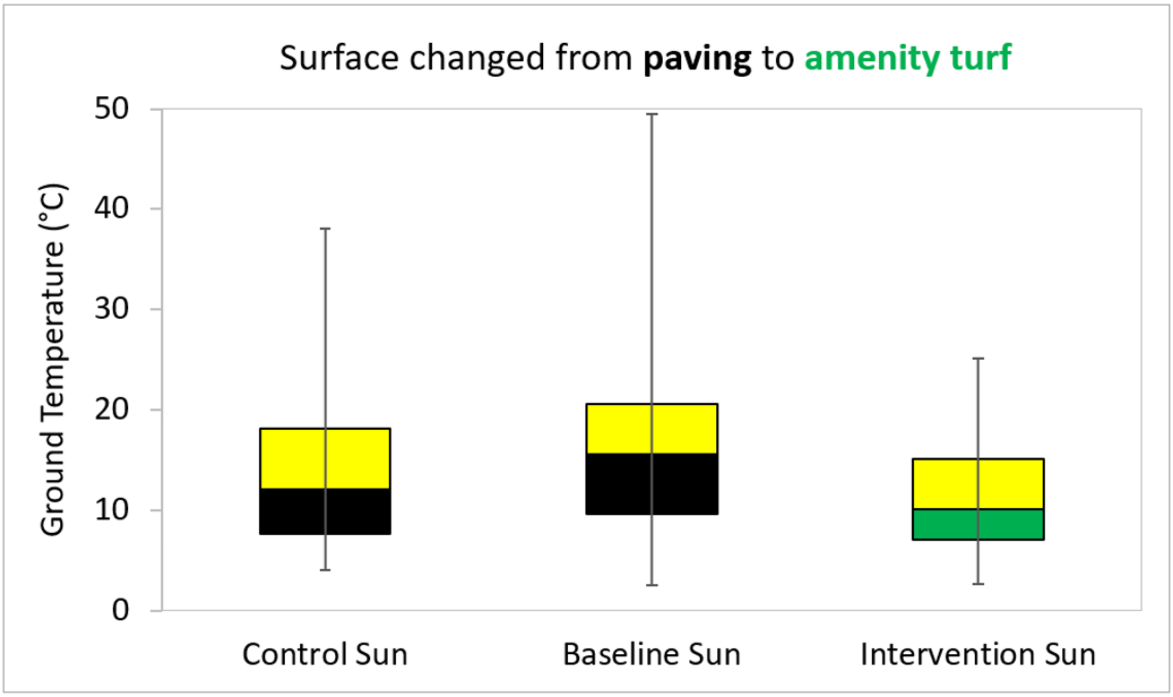

Figure 33:Ground temperature box and whisker plots for control (paving), baseline (paving), and intervention (amenity turf). Loggers in full sun

[4] https://www.envi-met.com/

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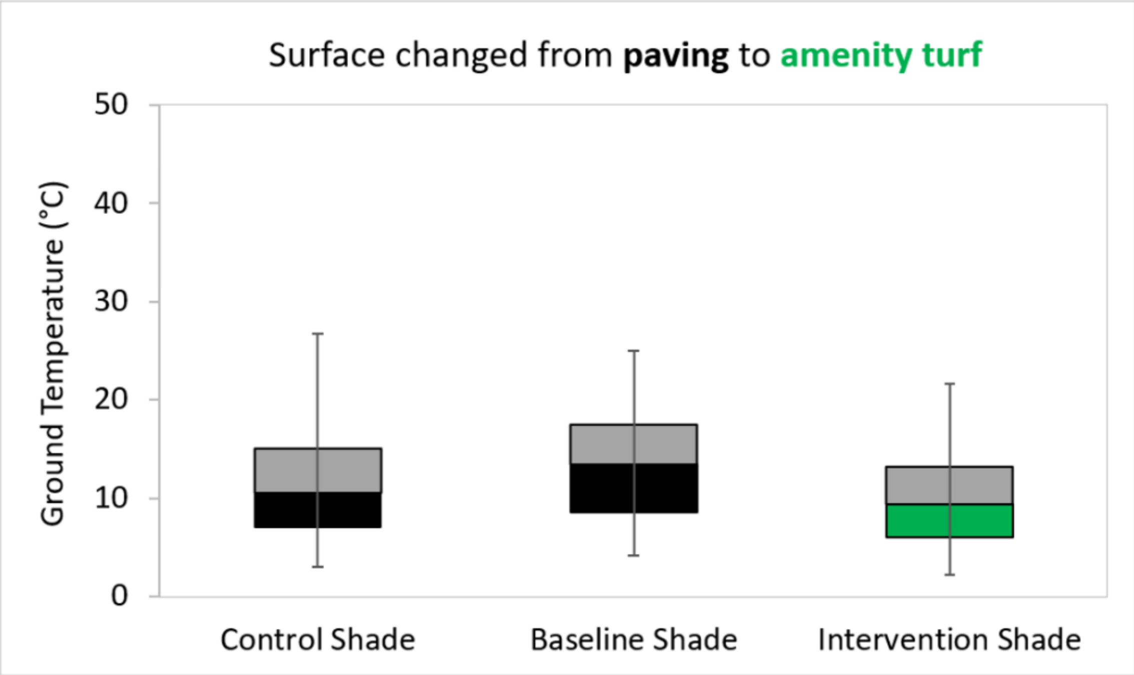

Figure 34: Ground temperature box and whisker plots for control (paving), baseline (paving), and intervention (amenity turf). Loggers in shade

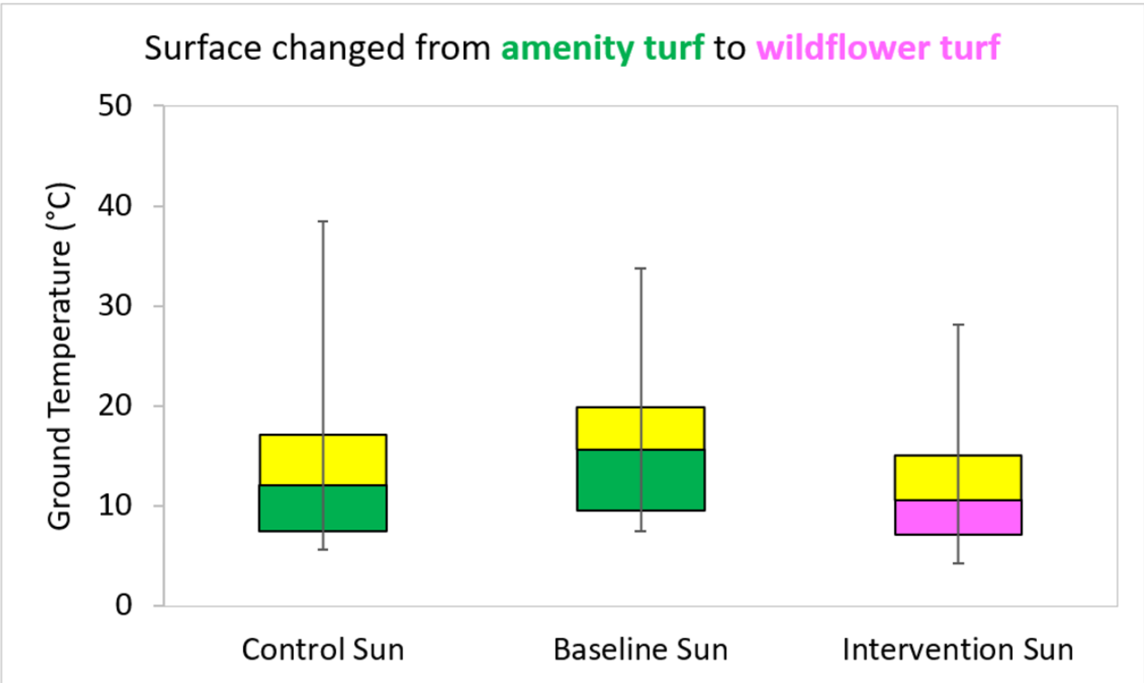

Figure 35: Ground temperature box and whisker plots for control (amenity turf), baseline (amenity turf), and intervention (wildflower turf). Loggers in full sun

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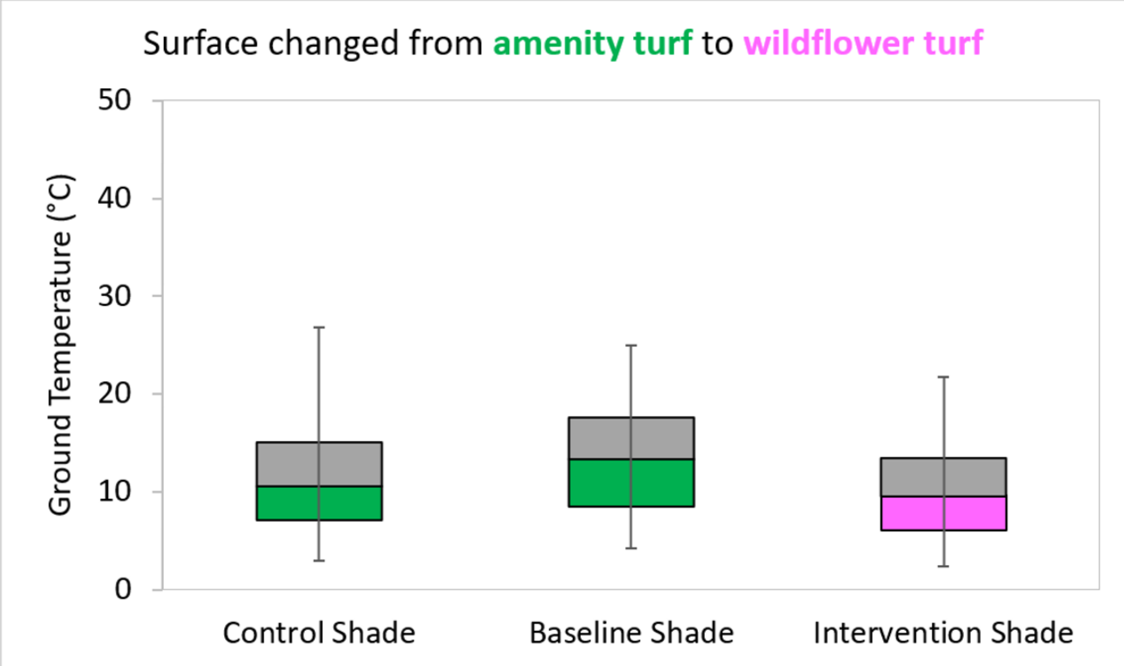

Figure 36:. Ground temperature box and whisker plots for control (amenity turf), baseline (amenity turf), and intervention (wildflower turf). Loggers in shade

Detailed ground temperature monitoring has revealed a clear difference in ground temperatures between baseline and intervention periods. Those contexts in full sun that have seen their ground condition changed from paving to amenity turf, have yielded a reduction in ground temperature. **Average ground temperature has decreased by approximately 5°C, with maximum temperature reduction of 24°C. For those amenity turf areas in full sun which were replaced with wildflower turf, average temperature has also fallen; by approximately 4°C, with a reduction in maximum temperature of approximately 5°C**. Although modification of ground conditions in shade conditions has yielded a much more subtle affect, there is still a small reduction in ground temperatures where paved areas were replaced with amenity grass, or amenity grass upgraded to native wildflower turf. Replacing hard surfaces, such as asphalt and concrete, with vegetation can yield benefits in the context of reducing the urban heat island effect. The ground temperature monitoring in West Gorton has provided powerful evidence for the temperature benefits of replacing hard paving with different types of grass.

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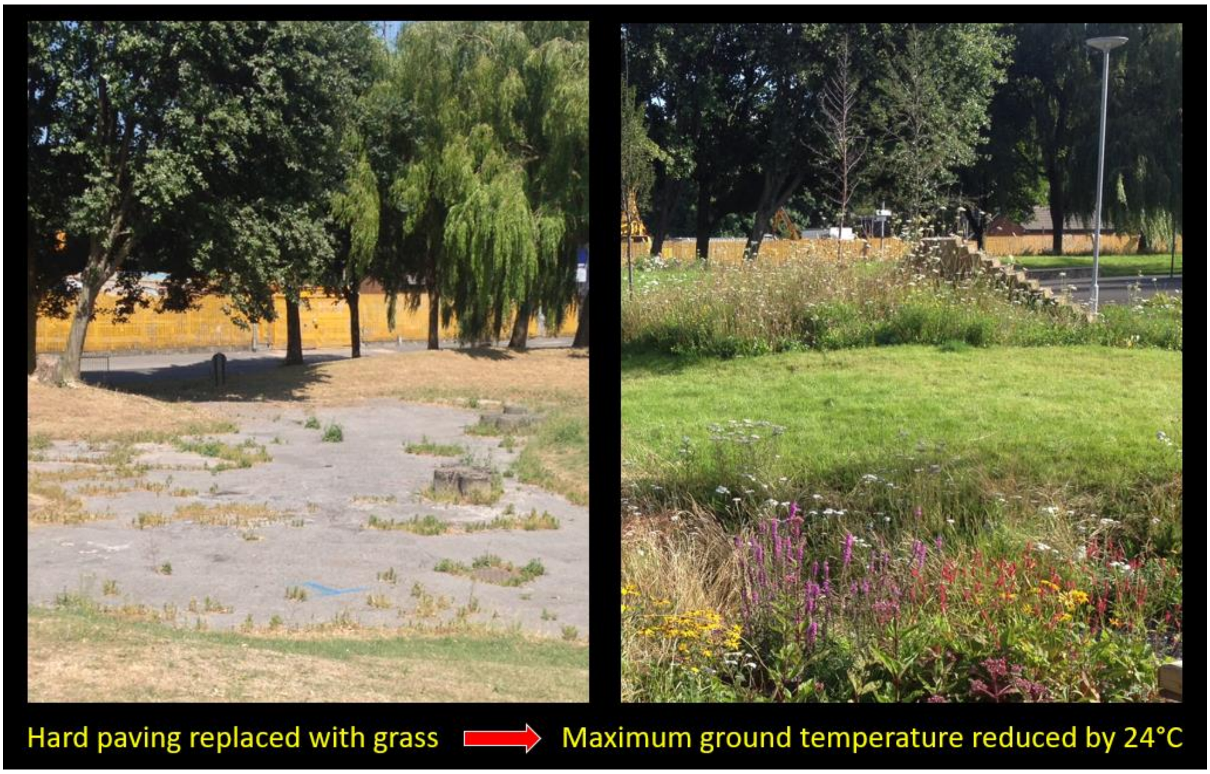

Figure 37: Illustration of the changes in the area in paving after the intervention.

6.2 Green Space Management - Biodiversity (Challenge 4)

See D2.3 Monitoring and Evaluation of Environmental Objectives.

The biodiversity indices were calculated for the Demonstration Area before and after the interventions. To express the measure of biodiversity, the Shannon (Shannon-Wiener) Diversity Index (H') is used. The Shannon Diveristy Index takes into account the number of species present within a given area or habitat - i.e. the richness, and their relative abundance with that area or habitat - i.e. the eveness. This equation was used:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

where: *H'* - Shannon diversity index; *S* - number of species
p_i - Proportion of individuals of i-th species within the dataset

6.2.1 Impact - Baseline vs Intervention

Three biodiversity surveys were carried out in Parks A, B and C.

The Shannon Index values are presented in Table 6 for each of the three areas of the Park, and for the three periods of survey (2018, 2020 and 2022). The differencee between baseline and 'average' intervention values are also shown. Tree species diversity has increased, with the greatest uplift in Park B. Species diveristy with the ground-level vegetation category (such as herbeaceous plants, grasses and wildflowers) has also increased. The greatest uplift has been in Park B, closely followed by Park A. However, the diversity of shrubs has declined between the baseline and intervention time periods. Total species numbers for trees, shrubs and ground-level vegetation are shown below. With

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the exception of the shrub catergory, total vegeation species have increased, with the biggest uplift in ground level vegation - up from 24 to 80 species (on average across the three parks).

	Park	Species Diversity			Outcome
		Jul-18	**Jul-20**	**Jul-22**	
		Baseline	Intervention	Intervention	Intervention* vs Baseline
Trees	**A**	1.50	1.95	1.91	+0.4
	B	0.69	1.34	1.33	+0.6
	C	1.50	1.92	1.94	+0.4
Shrubs	**A**	0.69	1.39	1.36	+0.7
	B	0.64	0.02	0.04	-0.6
	C	1.59	0.76	0.77	-0.8
Trees & shrubs	**A**	1.62	1.93	1.90	+0.3
	B	1.04	0.29	0.29	-0.8
	C	2.12	1.03	1.02	-1.1
Ground-level vegetation	**A**	1.32	2.59	2.60	+1.3
	B	2.30	3.84	3.79	+1.5
	C	1.79	2.28	2.27	+0.5

* Average of July 2020 and July 2022

Table 6 Species counts for West Gorton Community Park - Before and After Intervention.

	Park	Species Count			Outcome
		Jul-18	**Jul-20**	**Jul-22**	
		Baseline	Intervention	Intervention	Intervention* vs Baseline
Trees	**A**	6	11	11	+5
	B	2	5	5	+3
	C	4	9	9	+5
Shrubs	**A**	2	7	7	+5
	B	2	2	2	0
	C	6	4	4	-2
Trees & shrubs	**A**	8	18	18	+10
	B	4	7	7	+3
	C	10	13	13	+3
Ground-level vegetation	**A**	25	72	76	+49
	B	27	80	84	+55
	C	20	84	86	+65

* Average of July 2020 and July 2022

Table 7 Shannon Index scores for West Gorton Community Park - Before and After Intervention.

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6.2.2 Biodiversity Outcomes

Biodiversity increase was a key driver. Through detailed baseline and intervention surveys covering four years, the Park has been a **success in enhancing floral biodiversity**. The uplift in biodiversity has been driven by the extensive new planting carried out during the implementation and protection of a large number of mature trees. There are approximatey 50 new species within the ground-level cover catergory, consisting of a diverse mix of native wildflowers, grasses and ornamental plants. There are also 13 new tree species, including flowering and fruiting trees.

Prior to construction, two areas (Parks B and C) were dominated by rough ground and a semi-natural grassland appearance. These areas had a more diverse assemblage of ground-level species than their managed counterpart in Park A. They also contained a small number of different types of shrubs, which had established naturally. These were removed during site clearance prior to constuction of the new Park. Although it includes new shrub planting, this is quite limited with a large number of beech hedges planted on the park boundaries. There has been some **loss of the naturalised shrubs** between the baseline and intevention survey periods. This has driven the decline seen in Table 6 and Table 7.

Biodiversity can be affected by greenspace maintenance. Biodiversity scores vary slightly between the the two post-intervention surveys (2020 and 2022). **A small number of trees and herbaceous plants failed** and were not replaced. Areas of poor upkeep, particulary in Park A, have led to the encroachment of weeds, including nettles, thistles, plantains and meadow grass (Figure 38). The presence of weeds has partially offset the Shannon Index scores in terms of declines brought about by failed plants. Despite the minor changes, the overall picture is one of success with enhanced biodiversity.

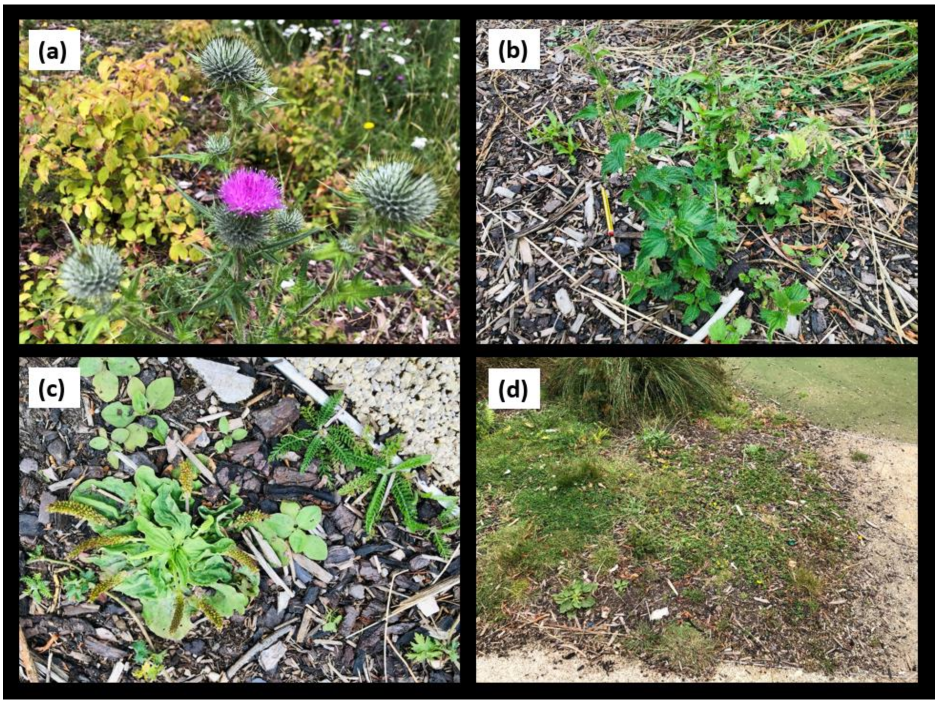

Figure 38 Weeds in Park A. a) thistles, b) nettles, c) plantain, d) grasses. (Source: Professor James Rothwell, July 22)

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6.3 Water Quality (Challenge 2)

See D2.3 Monitoring and Evaluation of Environmental Objectives.

6.3.1 Background and Context

The ability of the NbS features to ameliorate and reduced contaminated runoff was also investigated. The heavy metal content of runoff waters was assessed, together with the impact of road salting.

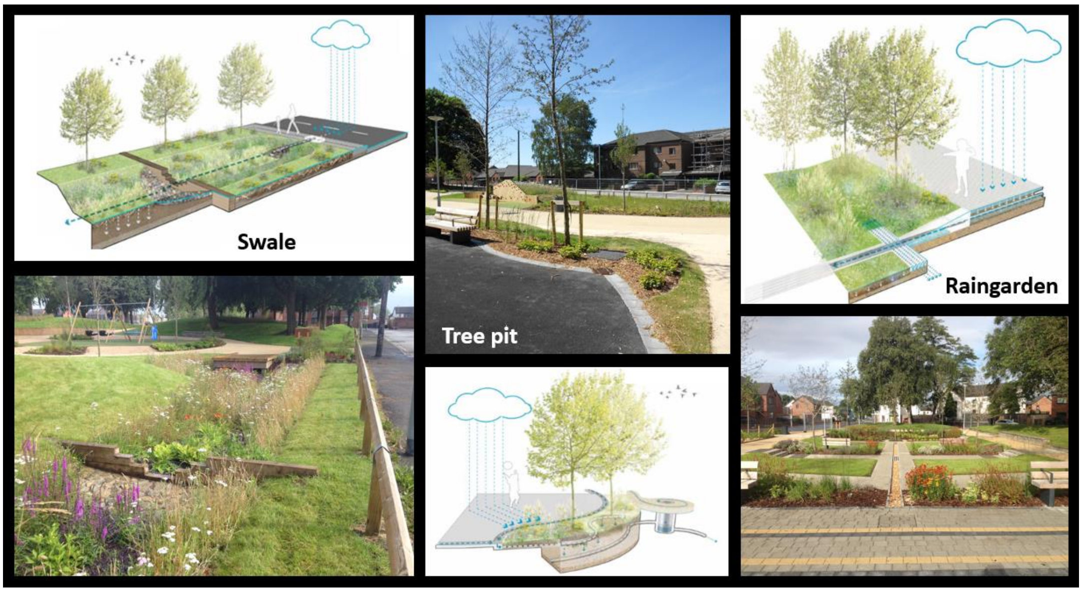

Figure 39 Photos and schematics of the NbS features in the West Gorton Community Park. (Source: Photos: Professor James Rothwell; Schematics: BDP)

Sampling and analysis of stormwater from the NbS features has shown that heavy metal concentrations in road runoff are higher than those leaving the swales in Park A and B. Heavy metal concentrations are also lower in water leaving the raingarden in Park C. The mechanisms responsible for the lowering of heavy metal concentrations are likely to be the dilution of contaminated waters with clean water inputs within the NbS feature (rainfall and clean surface water), or retention of heavy metals within the soil plant system of the NbS feature, or a combination of both. **Swales and the raingarden reduce heavy metal concentrations in runoff.**

Conductivity monitoring has shown that road salt application is washed into the swale in Park B. Conductivity values are extremely high for a surface water, falling into the saline category. Although the values are high, they do not persist through the swale to the monitoring location at its outlet. Therefore, saline waters are confined close to the inlet. Although saline can pose a risk to vegetation, the timing of this is in winter, not in the growing season. In fact, the vegetation in Park B swale has thrived in the 2022 growing season and appears to have been unaffected by the road salt inputs in the preceding winter, see Figure 41.

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Figure 40 Thriving vegetation in Park B swale, July 2022. (Source: Photo credit – Professor James Rothwell)

6.3.2 Exceedance of standards

Arsenic (As), Cobalt (Co), Chromium (Cr), Iron (Fe) and Nickel (Ni[5]) concentrations in stormwater runoff are low and do not exceed environmental quality standards. Cadmium (Cd) and Lead (Pb[6]) are also low but do exceed environmental standards in the inlet waters to the NbS features, but not the outlets (Table 8 below). However, there are two heavy metals that are present in high concentrations – Copper (Cu) and Zinc (Zn[7]), both of which exceed standards in the inlet waters of the swales and the raingarden. Although concentrations of Cu and Zn in the outlets of the swales and raingarden are lower than their respective inlets, concentrations still exceed environmental quality standards. A possible explanation for the high values is discussed in the section**, 6.3.3 Legacy Impacts on NbS Water Quality** below.

	Environmental Standard*	NbS inlet	NbS outlet
Arsenic	50	0.45	0.4
Cadmium	0.08	0.3	0.04
Cobalt	3	2	0
Chromium	5	2.97	0.95
Copper	1	7.12	2.56
Iron	1000	770	17.25
Nickel	4**	2.89	0.82
Lead	1.2**	1.32	0.31
Zinc	8	231	33.5

Table 8 Mean concentrations of heavy metals in NbS stormwater runoff in West Gorton, together with environmental standards and exceedance indicator (green below, red above standard). [8]

[5] As- Arsenic; Co - Cobalt; Cr - Chromium; Fe – Iron; Ni - Nickel
[6] Cd - Cadmium; Pb – Lead
[7] Cu - Copper; Zn - Zinc
[8] Environmental Quality Standards for Priority Hazardous Substances, Priority Substances, and other pollutants/substances ; **revised EQS values – Directive 2013/39/EU

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6.3.3 Legacy Impacts on NbS Water Quality

West Gorton has a long history of heavy industry with iron foundries, metal working and chemical works present from the 1850s to the 1960s. Site investigations conducted prior to the construction of the Park and its associated NbS features revealed extensive 'made ground', comprising of demolition waste, brick, ash and clinker. Soil samples from areas around the Park were analysed for heavy metals during this site investigation phase.

The soil samples revealed heavy metal contamination. The construction involved extensive landscaping works including cut, fill, offsite disposal of some soil, and the addition of new topsoil. Despite this, the water quality results from the NbS outlets reveals that some of this legacy contamination may remain, especially for copper and zinc. This historical debris is still in place below the NbS features, capped with topsoil. Given that the NbS outlets are connected to the sewer system, where runoff water will ultimately be processed and treated, the heavy metal levels leaving the NbS features are lower than direct road runoff delivered to the sewer system via traditional gully pot inlets. Therefore, the risk posed by this potential legacy impact is minimal.

6.4 Social and Participatory Benefits (Challenges 7 and *)

See D2.4 Monitoring and Evaluation of Social Benefits and Participatory Planning.

The research on the social and participatory benefits of creating the new Park focuses on three challenge covering aspects of both NbS process and NbS provision. These are drawn from the EU EKLIPSE approach originally developed by Raymond et al., (2017). This approach seeks to promote an assessment framework for the evaluation of climate resilience measures in urban areas. The **three areas of challenge are:**

- Challenge 7: Participatory Planning and Governance
- Challenge 8: Social Justice and Social Cohesion
- Challenge 9: Health and Wellbeing.

6.4.1 Methodology

A mixed methodological approach was adopted for the collection of the field data for social cohesion and justice, and health and wellbeing. This comprised of several iterations of direct behaviour observation and in-person surveys.

The directly observed behaviour data was collected using the validated MOHAWk[9] (Method for Observing Health And Wellbeing activities) tool, covering both social justice (e.g. bodily integrity and senses insights) and health indicators (e.g. vigorous physical activity). Observations were conducted at baseline (pre-intervention) during August 2018 and then in two follow-up waves (post-intervention), at the same time of year, in 2020 and 2021. Counterfactual data was collected simultaneously, in three matched comparison areas, for each wave of data collection. More than 4,000 direct behaviour observations were made.

An 'intercept' or 'face-to-face' survey was undertaken with more than 640 local people in two waves of data collection, using a quota to ensure representation of the local area. This involved approaching people in outdoor public spaces and asking them to complete a short questionnaire on behalf of the

[9] MOHAWk is a systematic observation tool for assessing three levels of physical activity (Sedentary, Walking, Vigorous) and two other behaviours important for wellbeing (Take Notice and Connect), in urban spaces.

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University of Manchester, usually in the vicinity of community hubs, such as at local newsagents or GP surgeries.

The UK's Office for National Statistics (ONS) measure of general happiness was used to estimate an individual's hedonic wellbeing. A new NOURISH (Neighbourhood flOURISHing)[10] tool was used to measure six of the reported social cohesion and justice indicators. Finally, participants were also asked how often they use their local outdoor neighbourhood spaces.

The NOURISH measure was developed with the local community, including with low education readers, and in accordance with key literature, to ensuring strong validity and that data reflected local priorities and a scientific basis. The measure of happiness is a validated measure, providing counterpoint to NOURISH. Asking local people about usage helps to validate the direct observations but also improves representation, capturing data from people who may not use the new local green space.

The data was collected in two waves: pre-intervention (June 2019) in the GrowGreen intervention West Gorton area (WG1) and one follow-up wave, post intervention (June 2021, WG2). Comparison data was collected simultaneously in both waves in a matched comparison areas, where no public space intervention took place.

6.4.2 Participatory Planning and Governance (Challenge 7)

The institutional level analysis of participatory planning and governance centres on three main areas: institutional learning, institutional capacity development and policy learning (Table 9).

Research Challenge Sub-Theme	Indicators	Summary results
Institutional learning concerning acquisition of knowledge and understanding	Degree to which institutions have enhanced their knowledge and understanding of nature-based solutions	1.6 - 4
Institutional capacity development	Institutional capacity development in responding to urban ecosystem challenges	1.6 – 3.5
Policy learning concerning adapting policies and strategic plans	Degree to which policies and plans have changed to incorporate nature-based solutions	Positive NbS uptake

Table 9 Institutional level sub-themes and indicators

Although the role of improved governance structures in driving forward more adaptive, resilient, and sustainable cities is widely recognised, a number of barriers exist which need to be overcome if 'transformative' measures are to prove successful. Within Manchester, it is arguable that a policy context has emerged which is favourable to supporting environmentally responsive planning and governance reforms. The findings are under three headings.

Research challenge sub-themes	Key institutional barriers overcome
KEY NbS LESSONS LEARNT:	
NbS can deliver multifunctional socio-ecological benefits	Path dependency, commitment Uncertainty

[10] https://www.research.manchester.ac.uk/portal/en/publications/neighbourhood-flourishing-nourish(959f6450-2861-4447-bc91-9b0df9ed273d).html

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NbS can support a practical understanding environmental systems Flexible messaging is important in community NbS education NbS can provide a context for urban regeneration NbS innovation can be delivered through multiple 'pathways'	Path dependency, uncertainty Commitment Path dependency, uncertainty
KEY AREAS OF ENHANCED NbS CAPACITY:	
Improved institutional embeddedness and NbS mainstreaming Promotion of a new way of 'seeing' the environment Extension and strengthening of stakeholder networks Improved reputational advantage	Path dependency, skills and resources Skills and resources, path dependency institutional fragmentation, limited representation, skills and resources, Skill and resources, uncertainty
KEY ASPECTS OF NbS POLICY LEARNING:	
Improved NbS integration within existing policy provisions Improved NbS integration within new policy provisions	Commitment Commitment

Table 10 Summary of key areas of NbS related institutional improvement

6.4.2.1 Socio-ecological learning (institutional and citizen level)

Both institutional and citizen levels indicators showed positive impacts on socio-ecological learning. At the institutional level a significant increase in NbS learning was demonstrated from an initial mean average baseline of 1.6 (on a scale of 1-5) to 4 at the end of the Project. There was no significant variation between different institutional groupings (public, private and charitable sectors). This is explained by a number of distinct areas of knowledge and understanding uptake.

The results suggest that the work has encouraged barriers related to 'path dependency' 'institutional commitment and 'uncertainty' to be addressed. Participants revealed an improved understanding of NbS multifunctionality and the relationship between theoretical and practical knowledge. This in turn helped them appreciate the role of being flexible and adaptive in thinking about how NbS innovation could be achieved and gaining an improved understanding of the role of 'place'. Of primary concern was the need for an improved commercial understanding of NbS to support future business cases.

Citizen-level analysis also showed a positive impact on citizen learning. Overall, interest levels were found to have risen during the course of the Project (from 'significant' levels of interest to 'very-significant' across 5 Likert scale groupings). By the end of the Project, citizens showed improved knowledge and understanding of those aspects of ecosystem services linked to 'provision', 'regulation' and 'culture'.

Institutional participants also demonstrated a significant uptake in their NbS capacity, reporting an uptake from a mean average of 1.6 at the start to 3.5 at the end. Again, there was no significant variation by institutional grouping, although there was a slightly higher initial baseline and endpoint for those private sector stakeholders. This can partly be explained by the primary emphasis on delivery rather than strategy formation.

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There is clear evidence of all institutional groupings having taken steps to integrate NbS within daily professional life. This was either through replication, or through improved training and guidance. Arguably, this places the city in a strong position to tackle NbS issues within an already strong sustainability driven policy framework. To a large extent this was aided by the development of improved internal and external networks. Whilst internal network strengthening and enhancement had helped overcome institutional fragmentation and silo-based working, external network improvement provided opportunities to widen participation and inclusion.

6.4.2.2 *Civic empowerment*

Impacts were also assessed in relation to the openness of participation, the legitimacy of knowledge and levels of trust in both decision makers and processes. 81 meetings were held with citizens providing opportunities for co-design-based engagement at each of the main phases (Baseline, Concept Design, Sketch Design, Construction and Post-Construction). Both the techniques used for data collection/decision-making and the types of meeting held were variable and aimed to support flexible engagement. Clear attempts were made to capture different age groups and to account for ethnic and gender-based diversity. It was estimated that 70% of participants were women, 40% were from ethnic minorities and 70% were from either younger older age groups. All participants gave examples of how they felt their involvement in the process had served something positive. By being able to see changes on the ground that they had help promote, they felt that they had been listened to. As a result, participants recorded positive levels of trust in both decision-makers and procedures.

6.4.3 Social Cohesion and Social Justice (Challenge 8)

The analysis for this section covers the research sub-themes of institutional learning, policy learning and social learning concerning ecosystem services and their functions/services. The results highlight positive impacts at both the institutional and citizen levels. At the **institutional level, interview participants highlighted that their NbS knowledge and understanding had risen from a score of 1.6 at the start to a score of 4 by the end of the Project** (on a scale of 1-5 with 1 being the lowest and 5 being the highest). Positive increases were noted for all institutional groupings. The **5 key areas of learning improvement** are summarised in Table 10 along with the barriers they have helped overcome. These show learning gains related to multifunctionality, environmental systems, community education approaches, urban regeneration and the nature of innovation. These knowledge improvements also had a **positive impact on policy learning** with notable impacts upon both existing and emerging policy outcomes, summarised in Table 11.

At the citizen level, community members noted that the Project led to an increase in their overall interest in NbS. This changed from a rating of 'significant interest' at the start to 'very significant interest' by the end (with 'very significant' the highest on a Likert scale of 5 groupings). Key areas of knowledge improvement were found to relate to ecosystem service elements linked to 'provision', 'regulation' and 'culture'.

Change in institutional learning: Knowledge and understanding uptake from 1.6 to 4
Key lessons:
NbS can deliver multifunctional socio-ecological benefits: Improved recognition of range of NbS benefits that can be deployed in combination. Stronger understanding of synergy between natural environment and socioeconomic benefits (Barriers overcome: Path dependency, commitment)

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NbS can support a practical understanding environmental systems: Enabling participants to engage at multiple decision-making 'entry points' enabled stakeholders to understand 'how the environment work'. Supported understanding of link between theory and practice. (*Barriers overcome: Uncertainty)* **Flexible messaging is important in community NbS education:** NbS terminology can be overly abstract for citizens. Encouraged development of alternative narratives for communication. *(Barriers overcome: Path dependency, uncertainty).* **NbS can provide a context for urban regeneration:** NbS understood as a key driver for 'place-making'. Multifunctional NbS solutions with strong socio-economic co-benefits seen as key to community improvement and enhanced pride. *(Barriers overcome: Commitment).* **NbS innovation can be delivered through multiple 'pathways':** NbS innovation opportunities exist beyond technological solutions. Innovation also rests in place adaptation and the role of integrated approaches. *(Barriers overcome: Path dependency, uncertainty).*

Table 10 Institutional policy learning: Key findings

Key lessons:
Improved NbS integration within existing policy provisions: Improved evidence and associated narrative to support existing proposals. Role of 'Wuhan' experience and exchange key to 'sponge city' learning. *(Barriers overcome: Commitment).* **Improved NbS integration within new policy provisions:** Appreciation of links between flood risk improvement and community benefits key driver of strategies such as 'Our Rivers, Our City'. *(Barriers overcome: Commitment).*

Table 11 Institutional learning: Key findings

The findings show that the Project had a significant impact upon those involved. All **respondents interviewed argued that they had benefited from an increase in NbS capacity. This was reflected in a shift from an overall NbS capacity rating of 1.6 at the start to one of 3.5 at the end of the Project**. There was no obvious trend between institutional groupings. **Four key areas of NbS capacity improvement were identified** by respondents. These are summarised in Table 12 along with the barriers they address. They relate, in turn, to NbS embeddedness and mainstreaming, NbS visioning, network enhancement and development and reputational competitiveness.

Change in institutional capacity: NbS capacity uptake from 1.6 to 3.5
Key lessons:
Improved institutional embeddedness and NbS mainstreaming: NbS now embedded within organisational priorities and values. New NbS projects being supported by local government with new educational and training arrangements within charitable and private sectors. *(Barriers overcome: Path dependency, skills and resources).* **Promotion of a new way of 'seeing' the environment:** Ability to now read landscape through "NbS lens". Enables existing features to be understood and future NbS options 'visioned'. *(Barriers overcome: Skills and resources, path dependency).*

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Extension and strengthening of stakeholder networks: Evidence of new networks formed both inside and outside organisations. Has supported ability to work on boundary of existing NbS knowledge and share new ventures. Traditionally separate units and bodies now working collectively. *(Barriers overcome: institutional fragmentation, limited representation, skills and resources).* **Improved reputational advantage:** Private sector able to demonstrate commitment to NbS and 'evidence-based' track record of experience. Key to client interest and future NbS roll-out. *(Barriers overcome: Skills and resources, uncertainty).*

Table 12 Institutional capacity: Key findings

6.4.3.1 Civic empowerment

Citizen engagement and co-design approaches were adopted with neighbourhood level KPI assessment. The combined evidence shows that citizens in both West Gorton were engaged at multiple points of the cycle and that a variety of different engagement methods were used to enhance a co-design centred approached. Civic society representatives provided a clear community voice in both cases and it was notable that NbS based approaches were put forward and implemented by the community. Efforts were taken to target particular age groups. There was also a degree of commonality regarding attitudes and values towards urban nature. Both communities showed a clear interest in NbS solutions and were able to rank and prioritise favoured options. In West Gorton, respondents were able to distinguish between personal preferences and those they thought would have greater climate change impact.

The Project led to an increase in citizen trust in the power of procedures. Respondents also felt that their involvement had achieved something, leading to sense of personal and community pride. Although NbS engagement and delivery had clear played a role in citizen trust levels, it was also clear that wider variables were at play. The decline in trust in decision-makers reflected broader regeneration concerns related to poor maintenance, of street lighting, vandalism, and anti-social behaviour.

Evidence of active community engagement: 81 meetings/events were held with citizens in West Gorton. These were at multiple entry points throughout the decision-making cycle. **Use of varied and flexible approaches to co-design:** Activities were focused on collaboration rather than information provision. Techniques varied from collective sketch design workshops to community planting. **Evidence of diverse and inclusive decision making:** 70% of participants were women, 40% were from ethnic minorities and 70% from younger or older age groups. **Variations in attitudes towards trust:** Engagement in NbS activities and subsequent delivery had clearly impacted trust levels. However, these were offset by wider expectations from decision-makers.

Table 13 Civic empowerment: Key findings

6.5 Social Cohesion, Justice, Health and Wellbeing (Challenge 9)

Communities already classified as vulnerable are likely to experience climatic impacts in a disproportionate manner. NbS can play a key role in promoting social co-benefits which help build resilient communities and avoid the potential exacerbation of existing concerns. The Project used the MOHAWk observation tool with additional data collection using community surveys or public records.

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6.5.1 Social Justice and Social Cohesion

The main research sub-challenges associated with this challenge area include bodily integrity; senses, imagination and thought; structural aspects and cognitive aspects. On the whole**, the research findings show that the NbS interventions have had a positive impact on over time**. Indicators for bodily integrity sought to assess the extent to which individuals within the communities were able to feel comfortable both within themselves and their place within the surrounding environment. There was an increase in citizens using target green spaces which had benefited from NbS intervention. Results for overall community safety levels following NbS intervention were however mixed. Between pre and post greening, there was a marginal decline in perceived safety. This contrasts to reported improvements in being fairly treated in the same location. As discussed earlier, this is likely to be associated with a spike on post COVID-19 crime rather than NbS failings.

A further impact was the percentage of people taking notice of their environment. This indicator served to assess how NbS provision had stimulated the senses, encouraged imagination and provoked nature-based reflection. The area recorded positive uptakes in 'awareness' of the natural environment as a result of the various NbS contributions.

Measures of green space access and provision provided a useful marker of overall provision but it is noteworthy that none of the NbS interventions were of a scale to significantly impact upon the indicators.

NbS can enhance the senses, imagination and thought: Community members were found have increased the extent to which they were taking notice of the environment (6.3% pre-greening and 65.9% and 50.6%) in two post-greening surveys **NbS can promote structural aspects of social cohesion:** Significant structural impact improvements were found for two main indicators. Levels of community interaction improved in both West Gorton (27.6% pre-greening and 49.1% and 42.3% post-greening). Levels of community integration were also found to increase following NbS deployment (44.6% pre-greening and 54.7% post-greening) and in Olbin (21% pre-greening and 45% post-greening).

Table 14 Social cohesion and social justice: Key findings

6.5.2 Health and Wellbeing

The final areas of research activity related to social impacts centred on health and wellbeing. **The majority of the indicators chosen for evaluation were based around measures of physical activity**. Here a particular focus was evaluating the degree to which NbS can promote those activities found to promote 'long term' health and wellbeing improvements. There were positive increases for both the number of people undertaking moderate levels of physical exercise and the number of teenagers/young people walking or playing in the target areas. Indictor assessment related to vigorous activity and walking showed a substantial increase between pre-greening and post-greening assessments.

NbS can promote increased physical activity: Substantial increases between pre- and post-greening were found for indicators relating to measures of vigorous physical activity, moderate physical activity, and physical activity be gender, age and ethnicity. **Levels of physical activity are likely to be impacted by NbS design:** Variations in activity levels across the Demonstration products are likely to affected by the approach taken to NbS. Although the Demonstration Project was based around three distinct zones across a single site, designers attempted to maintain both 'openness' and 'connectivity'.

Table 15 Health and well-being: Key findings

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6.5.3 Comparison Site Results

The NOURISH (Neighbourhood flOURISHing)[11] tool was used to measure six of the reported social cohesion and justice indicator Based on a comparison site, the findings across the use of the outdoor space and "feelings" (Challenge 8 and 9) are summarised:

Outdoor Space - outdoor space usage was initially higher in the Comparison Area at baseline, where the average participant reported using these spaces at least once in the last four weeks. Reported usage increases substantially in both areas over time, with the average participant using these spaces two-to-three times per week at follow-up. However, the increase in West Gorton is almost twice as large. National and regional research shows that local outdoor space usage increased during the COVID-19 pandemic.

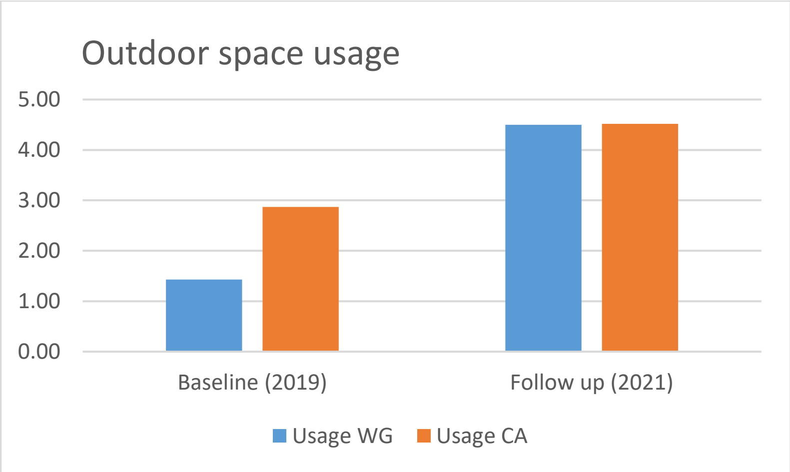

Figure 41 Bar charts depicting changes in local outdoors space usage over time

Feelings - The overall feelings are higher in West Gorton at baseline but both areas show decreases over time. This is driven by deteriorations in a sense of safety and trust in both areas, which may link to reported increases in crime locally. Respect measures whether people perceive themselves to be feel fairly treated and this has decreased in West Gorton but not in the Comparison Area.

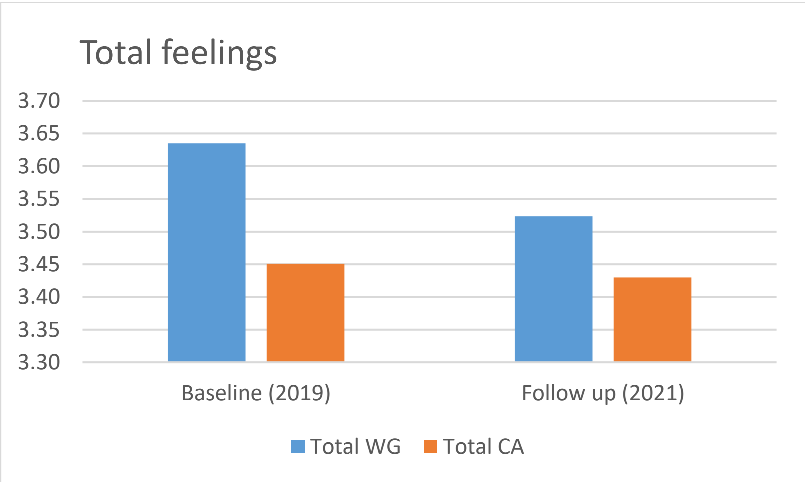

Figure 42 Histogram showing overall Feelings scale scores for West Gorton and comparison area before development (2019 and post-development (2021)

[11] https://www.research.manchester.ac.uk/portal/en/publications/neighbourhood-flourishing-nourish(959f6450-2861-4447-bc91-9b0df9ed273d).html

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6.6 Economic Objectives (Challenge 10)

See D2.5 Monitoring and Evaluation of Economic Objectives

A Cost Benefit Analysis (CBA) was carried out by Trinomics[12]. CBA is used in policy analysis to assess the overall benefits of a policy option compared to its costs and can also be used to assess the relative merits of alternative options available to decision-makers. CBA is a preferred policy tool in decision-making because it provides a 'decision rule' on whether an option can be justified for implementation, using the benefit-cost ratio (BCR). If a BCR is greater than 1, then the investment produces higher quantified benefits than the costs incurred to deliver them, and the investment is justified in economic terms. CBA can be used to compare benefits and costs that occur at different times over a long time period (say, 25 years), by discounting future costs and benefits to present day terms, allowing for options to be compared on a 'like for like' basis.

In public policy, the range of benefits and costs extend beyond purely financial items (expenditures and revenues) to consider a broader range of non-financial or non-market benefits, typically reflecting environmental or social outcomes, in what is referred to as 'social cost-benefit analysis'. This approach is applied here, using a discounted cash flow analysis over 25 years, discounting future costs and benefits using a real discount rate of 3% (as recommended by the EC's Better Regulation Toolbox[13]).

6.6.1 Quantifying Costs

A range of costs are used in the economic analysis, drawn from estimates and quotes. The capital cost (CAPEX)[14] and operating costs (OPEX),[15] as well as the year during which these costs occur, can be found in Table 16.

Activities	**CAPEX**	**OPEX**	**Year**
Design	€ 134,377		2019
MAIN NbS PARK Park A - The Woodland Zone	€ 350,120		2020
MAIN NbS PARK Park B - The Meadown Zone	€ 213,576		2020
MAIN NbS PARK C - The Plaza Community Zone	€ 291,033		2020
Pocket Park 1 green space improvement West Gorton, Rostron Gardens	€ 47,023		2020
Pocket Park 2 green space improvement in area West Gorton, Hyde Road	€ 9,152		2020
Pocket Park 3 green space improvement in area West Gorton, Rostron Road Arches	€ 16,501		2020
Extra Costs[16]	€ 554,958		2020
Maintenance costs		€ 20,882 annually	2020-2043 (25 years)
TOTAL	**€ 1,860,938**	**€ 283,795**	

[12] Project partner - Trinomics B.V. is a consultancy firm offering bespoke policy advice related to energy, environment and climate change issues.

[13] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

[14] One-time expenditures. Here, CAPEX costs include construction costs, material costs and planting costs

[15] Ongoing expenses incurred from the normal day-to-day running of the park. Here, OPEX relate to the following maintenance costs: labour and materials

[16] Prelims, Overheads, Profits, Compensation Events

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Table 16 Cost inputs used in the analysis

The CAPEX figures are derived from information included in contracts and receipts, and the total over the 25-year period is calculated on the assumption that half of the original CAPEX costs would be needed every 10 years, for restoration costs. Only half of the capital costs are expected to be needed for restoration costs as some activities such as earth moving would not be needed again. The OPEX figures were drawn from contracts as well as estimated from MCC staff. It was assumed that the OPEX costs from 2020 continue annually and will remain constant in real terms over time.

6.6.2 Quantifying Benefits

The creation or the restoration of urban green spaces has multiple benefits, including:

- **Carbon sequestration**: trees and vegetation absorb CO_2 via photosynthesis, some of which ends up being stored in the ground as soil organic carbon
- **Improvement in air quality**: trees and vegetation absorbing pollutants from the atmosphere
- **Enhancement of biodiversity**: by increasing the abundance and diversity of tree and plant species, and providing habitats for animal species
- **Heat reduction:** with branches and leaves filtering heat and providing shade to park visitors
- **Noise reduction**: leaves and branches on trees, shrubs, and herbaceous growth absorbing and deflecting sound energy
- **Avoided costs of rainwater treatment**: savings are made as water is diverted from sewers and ultimately mechanical treatment, and instead taken up by the park's vegetation
- **Mental health benefits**: parks and other green spaces have been proven to improve mental health issues such as depression, anxiety and stress
- **Physical health benefits**: positive impacts on physical health occur as residents visit the park and exercise there. Benefits linked to increased physical activity are calculated based on years of life gained as well as on reduced healthcare costs; and
- **Increase in residential property prices**: park restoration positively impacts the price of surrounding properties. This benefit partly overlaps with others, as the price increase is to some extent due to other benefits of the park, such as noise reduction and improved air quality in the surrounding area

This quantitative assessment focuses on three main types of benefits: avoided costs of rainwater treatment, physical health benefits, and increases in residential property prices. These were selected due to monitoring data being collected by the local public authority and the existence of tested methodologies to quantify benefits. The benefits included in the assessment are explored below.

6.6.3 Avoided Costs of Rainwater Treatment

The cost saving related to the volume of water diverted from the sewer network is calculated by multiplying that volume of water by the cost of treatment per m^3. The volume of water diverted from rainwater treatment amounts to **6,665 m^3** per year, an estimate which draws from monitoring data collected on-site and provided by UNIMAN. Treatment costs are estimated at **EUR 0.150 / m^3**, based on 2012 data on surface water management in combined sewer systems provided by United Utilities, the provider of water and wastewater services in North West England. The costs were converted from GBP to EUR and adjusted to take into account the inflation rate between 2012-2020.

When calculating the aggregate benefits until 2043, it was assumed that the avoided costs of rainwater treatment remain constant.

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Activity	Cost in GBP/m³ (2012)
Pumping	0.019
Sediment in Sewer	0.02
Combined Sewer Overflows	0.005
Detention Tanks	0.003
Treatment of Surface Water	0.058
Capital Maintenance	0.013
Cost per m³ of storm flow / year (2012 GBP)	**0.118**
Cost per m³ of storm flow / year (2020 EUR)	**0.150**

Table 17 Cost of Surface Water in Combined Sewer Systems (2012 GBP and 2020 EUR)

6.6.4 Increase in Residential Property Prices

Residential property prices are determined by the combination of physical attributes of the property (size, number of bedrooms, bathrooms etc) as well as locational attributes (e.g., distance to city centre, shops, schools, hospitals). One such attribute influencing the value of a property is its proximity to high value green space. Much evidence exists across studies that high quality green space positively influences property prices within a close proximity. It is likely, therefore, that this renovation of a low quality, poorly serviced green space into a high quality, frequently visited recreation site, will reflect the increase in value through surrounding property prices.

The hedonic pricing approach, which is a widely used valuation technique for environmental and non-environmental amenities, uses transaction data to reveal homeowners' preferences.[17] However, as the Project was too recent at the time of the assessment, only a very small number of properties had been sold within that timeframe, which prevented the collection of reliable data on actual preferences (i.e., on changes in property prices in the surrounding area). Therefore, a literature review was used to extract a figure that could be used in this assessment. The focus was on identifying studies that used a hedonic pricing approach to measure the impact of park or green space restoration in urban areas, in the UK or countries with similar socio-economic and cultural contexts. The increase in residential property prices in the surrounding area of the park is calculated by multiplying the number of properties within a 300-metre radius of the park to the average residential property value in West Gorton and by applying a property price lift percentage to this value.

The property price lift used in this assessment is **1.15%**, which corresponds to 25% of the value from the study from Breunig et al[18]. This value was retained over others found in the literature because this paper focused on the value of adding infrastructure to a low-quality green space, rather than exploring other NbS types or on a comparison of areas with and without green spaces, and as such more closely matches the subject of the present assessment. Nevertheless, applying only 25% of the study value, as a conservative assumption given the original analysis was undertaken in Australia and contexts may differ. Notably, this value closely aligns with the one used by the UK Office for National Statistics.

The increase in residential property prices in the surrounding area of the park is calculated by multiplying the number of properties within a 300 meters radius of the park to the average residential property value in West Gorton, and by applying a property price lift percentage to this value. A total

[17] Contingent valuation is an alternative approach which relies on a stated-preference (survey) method in which respondents are asked to state their preferences in hypothetical or contingent markets. However, this approach is usually applied to goods and services not traded in markets.

[18] Robert Breunig, Syed Hasan, Kym Whiteoak Value of playgrounds relative to green spaces: Matching evidence from property prices in Australia https://researchprofiles.anu.edu.au/en/publications/value-of-playgrounds-relative-to-green-spaces-matching-evidence-f-2

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of **927 dwellings** were identified within 300 meters of the park, based on information collected in the National Receptor database (2014).[19] Finally, the average property value in West Gorton, reaches **EUR 185,017** – according to the Rightmove database.[20]

Combined, this produces a one-off increase in value through surrounding properties of **EUR 1.86 million**.

6.6.5 Physical Health Benefits

Several approaches exist to economically quantify the physical benefits derived from access and use of green spaces, notably:

- The quantification of avoided healthcare costs derived from better physical health in the population
- The valuation of the years gained by avoiding death, with years of death averted being given a value (based on an annual Value for Statistical Life - VSL)
- The valuation of the years gained by living longer, with the extra years of life being given a value. Here, the value of the extra years of life can vary based on their quality (also called the Quality Adjusted Life Years approach - QALY)

Within each of these approaches, different methods can be used to estimate physical health benefits, which vary in terms of data requirements and analytical approaches. In this assessment, both the avoided healthcare costs and the valuation of years gained by avoiding death were calculated. These two values can be additive as they calculate the value to the user, but also the indirect value to the state of reduced healthcare due to a more active population. Valuation using VSL and QALY overlap as they both assign a value to extra years being lived. Ultimately, the VSL approach was retained because its data requirements matched more closely the monitoring data available.

6.6.5.1 Avoided Healthcare Costs

Avoided healthcare costs are calculated by multiplying a monetary estimate of the health care savings per marginal physically active visit to a green space (i.e., visitors either walking or undertaking vigorous activity) by the number of physically active park visitors.

The 2022 UK Green Book guidance on appraisal and evaluation (Annex A1)[21] contains recommended values in the monetisation of environmental benefits, including physical health benefits from nature, selected via a thorough literature review. The value given for **health care savings is EUR 3.85 (GBP 3.36 per) marginal physically active visit to a green space**.

The number of physically active park visitors was calculated using primary data collected with MOHAWk observation forms where observers record the numbers of people visiting a green space and differentiate between three levels of physical activity (sedentary, walking, vigorous). Observations were carried out in 2018 and 2021, each over a two-week period and each for 32 hours. The number of park visitors observed was then divided by 32 to obtain visitation per hour. To calculate the number of daily visits, the average hourly visitation was multiplied by the average hours of sunlight per day in

[19] The National Receptors Dataset (NRD) can be downloaded from the Defra Data Services Platform by registered users only.
[20] Available at: https://www.rightmove.co.uk/house-prices/west-gorton.html?page=1
[21] Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1063330/Green_Book_2022.pdf

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Manchester, **12.12**.[22] Table 18 shows that in 2021 there were an average of **350 daily park visitors** either walking or undertaking vigorous activity.

	Sedentary		Walking		Vigorous	
	2018	**2021**	**2018**	**2021**	**2018**	**2021**
Total count (32 hours)	58	241	384	698	84	225
Average number of visitors per hour	2	6	12	22	3	7
Average number of daily visitors	22	91	145	264	32	85

Table 18 Total and average hourly and daily park visitors, 2018 and 2021, per activity type.

To calculate the increase in physical activity caused by the park restoration project, the difference in visits between 2018 and 2021 was used. 50% of this increase was applied under the assumption that half of the additional users were undertaking exercise they would not otherwise have undertaken, while the other half had changed their recreational activity from a different location. An assumption of this nature is necessary to measure the induced physical activity resulting from the investment.

This produces an economic value of avoided healthcare costs of **EUR 125,000** annually or **EUR 1.8 million** in present value terms over 25 years.

6.6.5.2 Valuation of years of life gained

To monetise the benefits derived from years of life gained (i.e., avoiding premature mortality), the HEAT tool (Health Economic Assessment Tool),[23] was used as developed by the World Health Organisation (WHO) to conduct economic assessments of the health impacts of walking or cycling. The HEAT tool monetises the benefits from physical activity per year, which was then multiplied by the number of visitors based on available visitor activity data. Data on average daily park users was recorded using the MOHAWk approach (see explanation in **6.6.5.1 Avoided Healthcare Costs**). In addition, some assumptions related to distance travelled were made, based on the most recent and relevant data publicly available.

Distance travelled for each type of park visitor was calculated as follows:

- For sedentary visitors, it was assumed that distance travelled corresponds to the average distance to a park in Great Britain[24] multiplied by two (i.e., to go there and come back), which amounts to **0.518 km**.
- For walking visitors, the distance travelled was calculated by dividing the average number of walking trips per person in the UK per year by the average distance walked per person,[25] which amounts to an average of **1.19 km** per trip.
- For visitors undertaking vigorous activity, it was assumed that they undertook a physical activity equivalent to two times the amount walked by walking visitors, i.e., **2.38 km**.

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[22] Calculated from data available at: https://weatherspark.com/y/39871/Average-Weather-in-Manchester-United-Kingdom-Year-Round
[23] Available at: https://www.heatwalkingcycling.org/tool/
[24] As reported in Office for National Statistics (2018) UK natural capital: ecosystem accounts for urban areas. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/ecosystemaccountsforurbanareas
[25] As reported in Department of Transport (2018) Walking and Cycling Statistics, England: 2017. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/736909/walking-and-cycling-statistics-england-2017.pdf

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The value obtained by the HEAT tool for one person walking 1 km per day is a gain of **EUR 2.44** (**GBP 2.13 per year**, using the recommended value for a statistical life of GBP 3,035,000).

Following a similar approach as for the avoided healthcare costs, the difference in gains between 2018 and 2021 was calculated and applied 50% of this value to isolate the increase in physical activity caused by the park.

This produces an economic value of avoided healthcare costs of **EUR 140,000** annually or **EUR 2 million** in present value terms over 25 years.

Combining the avoided healthcare costs with the value to users of the personal health benefit produced from increased physical activity, an economic value of health benefits in present value terms of **EUR 3.8 million** is produced from the project.

6.6.6 Economic Outcomes

As explained above, capital costs of the Project are incurred in specific years, whereas operating costs are ongoing, and – for the latter – assuming constant annual costs over the 25-year period. Table 19 summarises total discounted costs and benefits over the 25-year period, including the Net Present Value (NPV) and Benefit Cost Ratio (BCR). Discounting future costs to the present day has the effect of reducing future costs in present value terms.

Items	Costs & benefits
CAPEX	€ 1,908,553
OPEX	€ 310,674
Total costs	**€ 2,219,227**
Avoided costs of rainwater treatment	€ 13,921
Increase in residential property prices	€ 1,859,161
Physical health benefits	€ 3,785,773
Total benefits	**€ 5,548,589**
Net Present Value (NPV)	**€ 3,329,362**
Benefit-cost ratio (BCR)	**2.50**

Table 19 Total costs and benefits, present value EUR 2022 (3% Real discount rate) 25 years

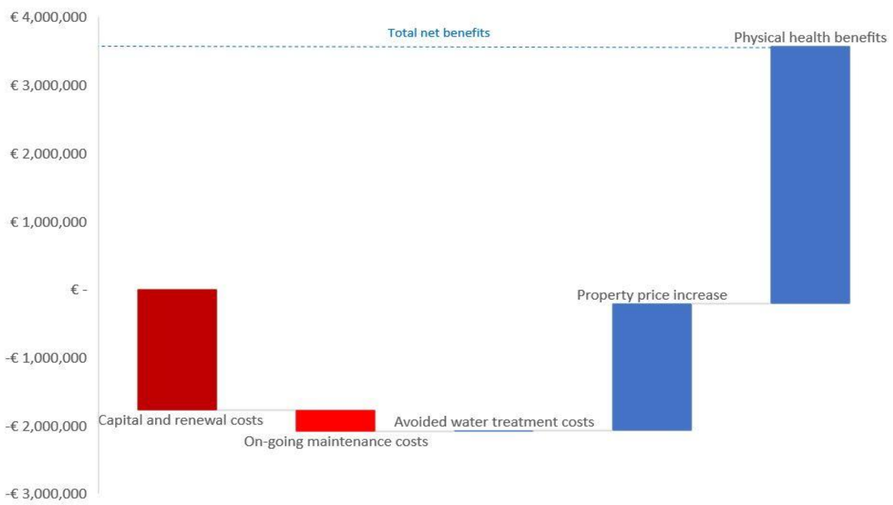

Figure 43 Overview of the present value costs and benefits of the GrowGreen Park in Manchester

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For every euro invested in the project over 25 years, 2.5 euros of benefit was produced. Net benefits produced from the investment were EUR 3.3 million over that timeframe. These results are robust to sensitivity tests of key assumptions used in the analysis.

It should be noted that many additional benefits of the project have not been quantified, including carbon emissions, biodiversity benefits, mental health benefits, heat and air quality improvements. As such, these results can be seen as conservative and the benefits likely higher.

Considering the quantified benefits themselves, the most easily monetised of all benefits (avoided stormwater treatment costs) was the smallest, with the remaining two benefits (property price increases and health benefits) being dominant.

7 Sustainability and Maintenance

SuDS requires a bespoke maintenance plan with consequent maintenance overheads. The park was previously a featureless, flat landscape but now has purpose build installations. Maintenance requires operatives to cut back vegetation, collect arisings, undertaking weeding and litter picking (litter in these areas tends to collect there as there in little opportunity to be windblown). This differs from a traditional park maintenance approach where ground maintenance is generally driving machinery e.g., sit-on mowers.

The system of water pipes woven into the design are integral to the functionality of the NbS and need to be kept clear of debris to ensure that rainwater can flow freely. They can be impacted by leaves from nearby trees collecting along the road kerbs and into the swales and rain gardens. Blocking the inflow and outflow pipes impacts on functionality.

There was a high specification standard for the play equipment, benches, and paving materials. If these are damaged or require replacement, they are harder to source and more expensive to replace.

Budgets are challenging across the public sector. MCC is no different and for the Park, the grounds maintenance department were provided with an uplift on their maintenance budget. The financial arrangements are as follows:

- The first two years of maintenance (by the construction contractor) were/are funded from the construction budget.
- The next three years of maintenance will be funded from capital receipt from the sale of land for development as part of the West Gorton regeneration programme.
- The main social housing provider, TGPL has contributed €200K.

It is hoped that a five-year maintenance funding arrangement will allow sufficient time for a realignment of budgets in the longer term. This process has proved helpful to inform other NbS developments in the city and there are discussions underway to look at the funding of new green spaces in the city.

Going forward, MCC will be renewing the wider grounds maintenance contract and will ensure that exceptions to the

8 Design Innovation

Design innovation was an important element and is highlighted by:

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- Incorporating a drainage design layer into a traditional park design had never been done before in Manchester.
- The design process was new in the city. Bringing all stakeholders together to input into the design drivers meant the Project was able to adopt an approach that ensured that the relevant KPIs were included in the landscape design.
- The process of designing rainwater runoff to redirect from the roads surrounding the Park as a NbS feature is a new approach in Manchester. Whilst there is a 'failsafe' outflow pipe into the main sewer system at the end of each swale system, the research fundings could demonstrate that these are not necessary. There is the potential for a business case for co-funding from a water company who could make savings on treating such water, which would normally enter their sewer. This has raised internal discussions within MCC's Highways Department.
- The sloping basketball area is the only non-permeable surface (Figure 21). It slopes gently towards an open drainage channel and bioretention tree pit and is an innovative feature which can be replicated. Similarly, in the plaza garden rainfall that falls on the permeable area is captured in a large liner under the plaza and redirected towards an ornamental rill, leading to a bioretention tree pit. It is worth noting that play is not hindered by the slope of the court and players take advantage by letting the ball roll back to them!
- There are subtle design features referencing the movement of water. For example, a large 'swirl' of ornamental mosaic pebbles which replicates a naturalistic stream, and the wooden sleeper check dams and grey slate mulch in the bottom of the swales
- Educational signage is a common feature in many parks but has not previously included any information about climate change and NbS. This was replicated following similar signage seen on the study trip to Wuhan in 2018, (Figure 44).

Figure 44 Park signage

The Manchester Demonstrator drew on other areas of the wider GrowGreen project:

- Green City Framework – [the Green City Framework is a template for cities starting on the journey of green infrastructure strategy development]. This was used to sense check processes and be a guide to make sure that action plan took account of relevant elements.

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- The Adaptation Pathways Approach - this is a dynamic adaptive planning approach pioneered in Europe by GrowGreen partner, Tecnalia. It aims to support the best and most appropriate decision making for a neighbourhood by providing NbS alternatives to change system outcomes. GrowGreen provided the opportunity to build an adaptation pathway approach for Manchester, delivering a 'one stop shop' for assessing NbS interventions locally. The approach aligned with the Net-Benefit Wheel developed in the Nature of Manchester. This looks at a strategic view at city level and a detailed work at district level providing:

    - A routemap on which NbS, including infiltration techniques and adaptation options can be implemented in West Gorton over time.
    - A long-term adaptation vision and objectives based on NbS to reduce surface water flooding.
    - Identify stakeholders who could be engaged to maximise adaptation to climate change.

9 Lessons Learnt

There have been a range of challenges encountered in the delivery, providing an opportunity for lessons to be learnt.

9.1 Design

- Project Briefs - Projects need a clear scope to ensure that all the client requirements are detailed, agreed and signed off by all stakeholders before the start of the procurement process. Early through the popularity of the site with local residents as well as the success of the NbS design features. Engaging with local Neighbourhood Officers was important in this process.
- Specialist knowledge - SuDS design requirements are more complex than a standard installation. To address this, the main landscape architect subcontracted a specialist drainage engineer. Consideration needs to be given to engaging a contractor with all the required skills. The ongoing engagement with technical specialists e.g., technical play knowledge is essential to ensure the design meets requirements as well has health and safety standards.
- Baseline analysis - Site surveys including soil testing and topographical surveys need to be early in the design process. Engaging the right people at the right point in the design process would have created a more effective and streamlined process of design and approvals.
- Standard specifications – where feasible the specification of standard materials in the design can eliminate issues with procurement and the requirement for commuted sums to be paid by the client for ongoing maintenance of any bespoke. For example, the design of highways element should, as far as possible specify standard highways materials to minimise installation and ongoing maintenance costs.
- Engagement of the delivery team to be a 'critical friend' during development of the project brief is important to ensure that key elements that could impede or impact buildability are identified and addressed.
- Stakeholder engagement - the combination of citizen consultation with stakeholder workshops enabled the design team to understand priorities from both sides. This influenced some of the procurement process.
- Existing frameworks – The advantage to procure from existing frameworks for both a landscape architect and a construction company meant that due diligence was already in

place. However, the availability of specialist contactors on the frameworks was not always forthcoming and contingency for this should be considered early on.

- Specialist contractors - The construction procurement process was challenging. Feedback suggested that the small size of the contract and a perceived risk of theft or damage to equipment on site were issues. A second procurement process was undertaken utilising a specialist landscape framework.

9.2 Stakeholder Engagement

- Citizens – Whilst the Project is a 'Living Lab', the surrounding community are real people with needs and priorities. The aspirations from the community were initially low. An initial request from residents was just for a new set of swings. Engaging with staff working in the local area to help facilitate engagements is needed ensure that it receives the full benefit of local input. It will also ensure the contractor's social value commitments are delivered (all MCC contracts with suppliers include a social value element of 20%).
- Flexibility - The most effective engagement method was a walk-in unit at a footfall hotspot (the local school at afternoon pupil collection time) where people were invited to discuss the design ideas with the landscape design team. Bringing the consultation to the community resulted in the largest numbers engaging.
- City departments – City administrations are complex organisations and responsibilities fall across different services and budgets. To deliver a project of this nature it is vital to have input from a range of different departments e.g., highways, grounds maintenance, parks, street cleaning and neighbourhoods. One example was the requirement of Highways to provide standard gulley drains. These entered the Park at a different level to the bespoke ones originally specified and additional work was needed to reprofile the levels.

9.3 Construction

- Statutory approvals - Statutory requirements e.g., road closures and diversions, planning permissions all bring additional risks to the cost and programme due to approval timescales.
- Design and Build - It is challenging to coordinate schemes on a 'construct only' contract as there are bound to be conflicts on the interface between design and contractor responsibilities. It is recommended to procure similar projects as design and build for centralised ownership of responsibility and risks.
- Skills – UNIMAN to provided supervision to ensure that the NbS features were correctly installed. This was due to a skills gap by the contractor and also to ensure the accuracy of installation required for the research equipment.
- Ground conditions - Significant amounts of Manchester has clay soils. Due to lack of permeability, these can significantly impact the viability and functionality of SuDs. Careful planning, and detailed site testing was used to mitigate this. For example, one of the bioretention tree-pits in the community plaza garden had to be redesigned to factor in the clay soil discovered during excavation works.

9.4 Monitoring and Impact Evaluation

- Sensors - There have been significant advances in smart environmental monitoring utilising wireless networks, cloud-based computing and the Internet of Things (IoT). This approach was considered, but a number of challenges prevented deployment. These were installation and coverage/connectivity issues, sensitivity and accuracy of devices. The lack of a suitable smart city platform in Manchester for the integration of smart environmental monitoring data was also an issue. The solution was to use of manual download sensors. These have worked well,

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but require frequent visits to download data, replace batteries, and check on sensor functioning. The frequent visits have served as an additional purpose such as to check on the NbS features and undertake any light-touch maintenance (e.g., clearing leaves from drain inlets/outlets).

- Non-sensor monitoring **–** The majority of the monitoring involved surveys, questionnaires, interviews, record keeping and reflective work. This has been more time-consuming than initially thought, especially for the acquisition of robust health, wellbeing and social cohesion data. Interview work with project partners and stakeholders has been extremely insightful, but the limited number of community members willing to take part in interviews has been a challenge. In retrospect the large number of participation and governance KPIs (Figure 14) requiring interview work could have been streamlined.
- Data capture timescales **–** The initial call for the Project required baseline pre-greening datasets (6 months prior to construction) and detailed high resolution post-greening monitoring (two years post NbS construction). Although baseline datasets could be extended using available historical data where feasible, this arrangement introduces uncertainly associated with monitoring a short ‘pre’ and longer ‘post’ intervention time period. For some KPIs, two years is not long enough to detect impact, e.g., where KPIs rely on the development and maturation of vegetation/trees. A significant issue has been COVID-19 and associated restrictions. This led to delays with the construction. Post-construction monitoring started in July 2020, meaning that the full 2 years of post-construction data cannot be captured before submission of the WP2 monitoring and evaluation report. This has an impact on both sensor and non-sensor data, particularly for KPIs where the second summer of data acquisition will be missed. It is anticipated that the data collected will however provide a full and rounded picture of the Park’s impact across all KPIs.

9.5 Management and Maintenance

- Budgetary **–** Standard municipal maintenance regimes are not wholly suited to NbS schemes. The original intention was to use a domestic household levy (€10 per annum to each property) for maintenance. This was vetoed by objections from a local politician. Their argument was this did not occur in other more affluent areas of the city. However, since then, the levy approach has successfully been implemented for new apartments adjacent to an existing municipal park, albeit with a more affluent occupier than in West Gorton. Senior leadership is required to support NbS and budgetary challenges require the creative thinking to address maintenance issues.
- Maintenance – A robust management plan will help ensure the ongoing successful maintenance of the landscape. SuDs need a bespoke maintenance schedule with the need for those responsible for maintenance have an understanding of the issues. This also raises the issues of the skills gap in NbS.

Although the runoff monitoring yielded excellent results, a number of issues were encountered during the two year monitoring period impacting on the hydrological performance of the NbS features. These were issues on the movement of water through inlets and outlets of the NbS features.

Blockages were a key issue and were caused by the following:

- Leaves and twigs
- Road surface debris, particularly during resurfacing work on adjacent highways
- Slate chippings from swales (redistributed by children)

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The routing of water into Park A swale was also affected by removal of road surface material at the kerbside during highway sweeping. These issues are shown in Figure 45.

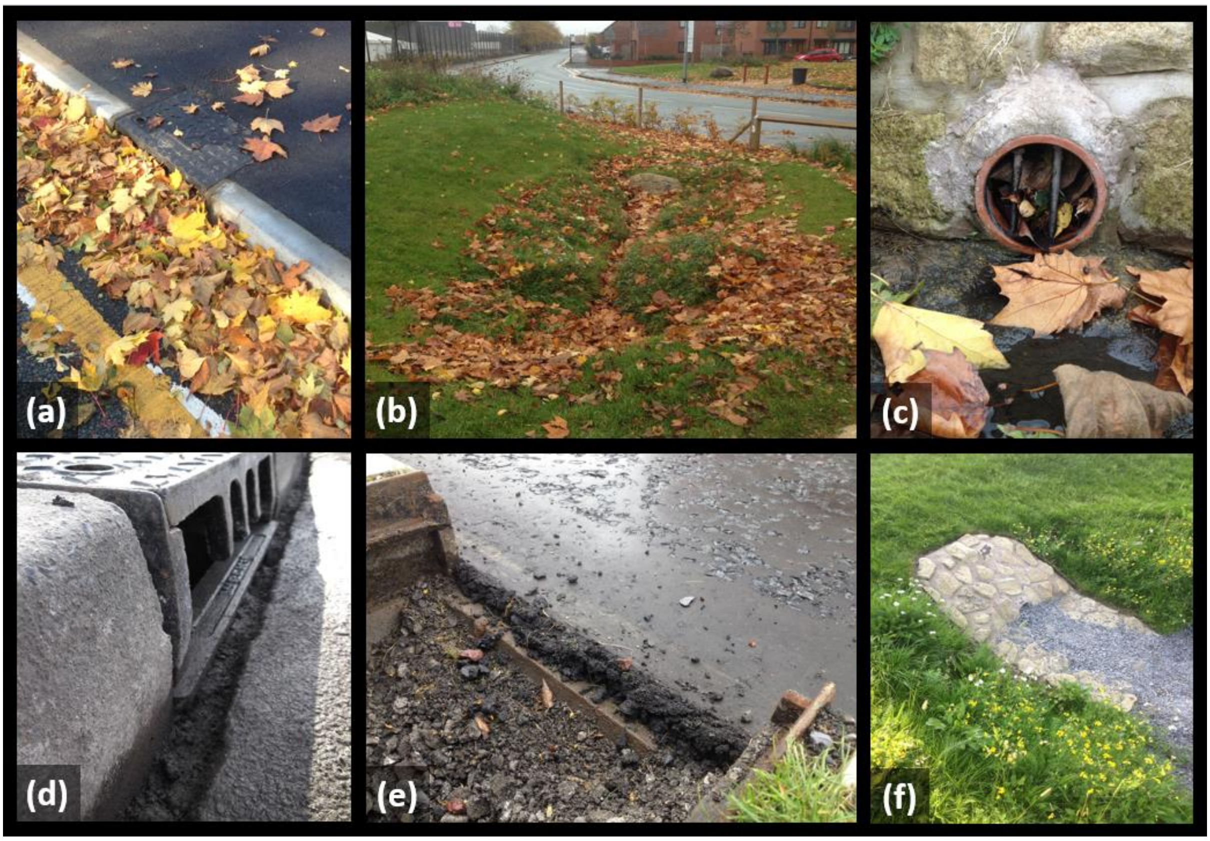

Figure 45. Park B Swale - leaves in the inlet (a), in the swale bottom (b), and in the pipework (c). Missing road material in front of Park A swale inlet (d), road debris following highway resurfacing works in the inlet of Park C swale, and slate chippings deliberately used to block headwall inlet in Park C swale (f). Photo credits: Professor Rothwell

- Design features – As the Park has become established, there have been a number of learning points from some of the design features:
    - Slate mulch was used in the bottom of swales with the aim to mimic the passage of water. Some of this has been removed and scattered, looking unsightly and it has the potential to block drainage pipes.
    - Drainage pipes have been occasionally blocked. There have been occasions when children have inserted slate mulch, drinks bottles and cans into the pipes. This has not been a deliberate act but part of children's play and curiosity. This is being addressed through ongoing engagement work with the local school and citizens.
    - Some of the drains from the highway are located near large deciduous trees. Leaves can cause blockages and this cannot be mitigated by municipal road sweepers due to the low frequency with which they visit.
    - Consolidated gravel paths used as a surface material has eroded away where it is located on a slope.
    - NbS features can dig into the topography (approx. 1.5M lower than the surrounding landscape) and require manual weeding and litter picking as they are not accessible to machinery with the associated costs of manual maintenance.

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- Highway drainage at the site periphery drains water from the highway. Due to the inlets becoming obstructed with leaves and litter, there have been incidences of flooding. This needs to be addressed via the maintenance programme or utilising the community group resources.

- Handover – It is important to ensure a smooth transition from the construction to the operational phase of the project. Often referred to as creating a "soft landing", this involves colleagues from all relevant departments in a formalised project closure and handover. It is important to ensure that the facility management arrangements form part of the project closure activities, responsibilities are well defined and the contractor's 'aftercare' processes and procedures are clearly understood.

10 Replication and Scaling up

During the Project timeline there has been significant progress towards awareness, knowledge and implementation of NbS projects in Manchester, alongside developments in regional and national policies.

10.1 Financial and Business Case Development

The total construction costs were approximately €1.4 million. The majority of this was funded by the EC. Currently it is challenging to calculate the actual financial return on investment since there are no obvious revenue savings or income generation opportunities stemming from the creation of the Park.

It has been used as a case study in a report on the value of urban nature-based solutions completed by the UK Green Building Council in 2022. The report, The Value of Urban Nature Based Solutions, May 2022 concluded that "*the benefits of NbS are often complex and may not easily generate direct financial value. In addition, the benefits can be distributed over a large and diverse range of stakeholders, requiring a wider assessment of benefits and value*" (UK Green Building Council, May 22).

It goes on to say that a key challenge to the valuation of NbS is "*the rigid framing of its value in direct financial terms for a limited group of stakeholders. The majority of NbS' value exists outside of these boundaries; indirectly benefiting a much wider range of third-party stakeholders. These can be considered as the positive externalities of NbS*."

This concept is demonstrated by the Cost Benefit Analysis (CBA) completed by Trinomics[26] which assesses the merits from a "whole society" perspective showing that over 25 years the West Gorton Park has a CBA of 2.5.

Considering the quantified benefits themselves, the most easily monetised of all benefits (avoided stormwater treatment costs) was the smallest, with the remaining two benefits (property price increases and health benefits) providing greater value. This neatly illustrates the dilemma faced by public agencies with responsibility for NbS ambitions in cities. Whilst these projects produce net benefits for society, the ability to attract external funding or co-funding is limited by the nature of the benefits produced.

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10.2 Living Lab Creation

Since opening in mid-2020 the Park has become a Living Lab. It is able to demonstrate what are often seen as theoretical elements of local and national strategy in a practical way. It has created a showcase project, and is a catalyst for discussion in MCC departments and with other city partners.

Despite COVID-19, more than 100 invited visitors have been shown around the site since it was opened. This has included visits from the Mayor and Deputy Mayor along with the politicians responsibilities for the city's environment portfolio, members of external organisations, the local television news and visitors from Europe. A link to a report on local television news is available via Twitter. The site has also been visited by representatives from the Environment Agency, a non-departmental public body, sponsored by the government's Department for Environment, Food and Rural Affairs (DEFRA), with responsibilities relating to the protection and enhancement of the environment.

UNIMAN have been instrumental in helping deliver tours/visits. The research elements and technical aspects have been brought to life through explanations and demonstrations by university researchers. In excess of 10 tours/visits have been accompanied by university researchers, helping facilitate the communication of the Park's aspirations and impact. The attendees have been universally impressed and have often gone away inspired to think about how they could replicate design elements within their own green spaces. In addition to MCC departments and external partners, It has become a Living Lab for university students. Geography students have visited for fieldwork and undertaken a number of research-oriented activities. The University has also established a new MSc course in green infrastructure. Details are available on the university's website. The course is the only one in the UK 100% focused on green infrastructure and attracts students from around the world including China and Iraq as well as the UK. The Park offers opportunities for students to undertake dissertation work and coursework using the location as a practical example of nature based solutions and make a contribution to addressing the NbS skills gap.

Figure 46 Reactions to the Park

10.3 Strategic Impact for Manchester

A green and blue infrastructure strategy and action plan for Manchester was originally published in 2015. This was refreshed in 2022, resulting in the Green Infrastructure Strategic Implementation Plan. This is a long term vision, available on the Council's website incorporating learning from GrowGreen. It is about changing behaviours, not just of citizens in their appreciation and understanding of the value of green infrastructure, but of different city departments in recognising that considering and delivering NbS as a response to the distinct challenge that urban environments present. The ambition is for it to be a mainstream commitment. The strategy has been recognised as a UK best practice exemplar by the Chartered Institute of Ecology and Environmental Management (CIEEM).

GrowGreen helped to support the commissioning of MCC's first 'River Valley Strategy', Our Rivers Our City. This is a significant step in identifying the services and value which the city's river valleys provide, as well identifying opportunities to improve them. It includes comprehensive mapping and ecosystem services assessments for the three main rivers of Manchester; the Irk, Medlock and Mersey. The strategy moves the city forward a further step towards 'sponge city' thinking (Figure 47) and has provided the evidence to support a successful €1M submission from a local NGO for government funding for river valley enhancements.

The Project has provided an abundance of promotion and networking opportunities, offering a global platform to share best practice, to continue collaborating, improving and learning. The collaboration with Wuhan has helped to embed sponge city concepts into strategic approaches. Manchester was the first North West city to sign up to the global Cities with Nature Network, a collaboration with cities around the world on NbS and green infrastructure delivery.

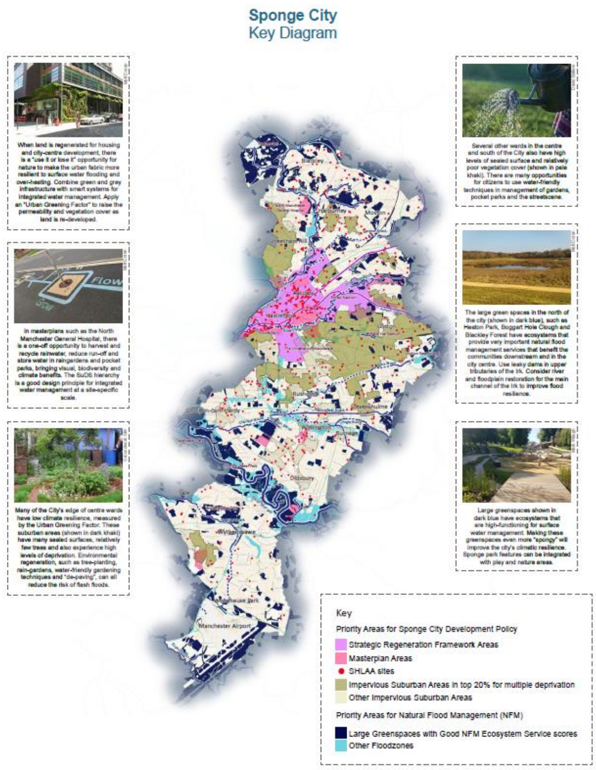

Figure 47 Example of the evidence base from Our Rivers Our City

10.4 City Impact

NbS work also forms part of the city's Climate Change Action Plan(CCAP). Progress against green and blue infrastructure actions is steered by the Green and Blue Infrastructure Board, chaired by the Director of Planning, Building Control and Licensing and attended by service leads. The aim is to deliver €180M of work on green infrastructure over the next five years.

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MCC has now appointed a Highways Sustainability Officer with a remit to look at developing SuDs solutions and standards. The aim will be to look at ways to retrofit these in existing highways as well as ways these can be included in planning permissions. Enforcing a stricter approach at the planning stage re NbS and SuDs in new developments is a certain way to accelerate change. As part of the CCAP, the Highways department are also developing a zero carbon strategy. There is also a Manchester SuDs group that brings together stakeholders in the city.

An example of this approach is the new city centre Mayfield Project. The website details the work taking place. A major mixed business and residential development with an investment value of €1.5 billion, is transforming a large brownfield area over the next 10 to 15 years. Central to this development is the creation of a new 2 hectare park, focused on the re-naturalisation of the River Medlock and integrated SuDs features. The park opened in September 2022.

Figure 48 Mayfield Park

A landscape centred approach is also being taken by the Victoria North partnership (MCC and development partner, Far East Consortium). The €4.5 billion project will deliver of 15,000 new homes across 155 hectares of Manchester's industrial landscape over the next 20 years. The development broadly follows the course of the River Irk from the north of the city into the city centre. Opening up access to and improving the sites around the river is seen as a key feature of this development, with seven new or improved green spaces celebrating this.

The city has been successful in bids for external funding (UK government) to alleviate flood risks. This will be used to combat flooding on both a local and wider catchment scale, focused on two areas. Firstly, clearing and upgrading the Manchester culverted watercourse network and secondly, reducing the size of areas which are at a risk of flooding by creating areas where controlled flooding can occur, away from residential areas.

In July 2022 an urban sky park has been constructed in the centre of Manchester. The National Trust[27] turned a 330 metre steel viaduct built in 1892 into a temporary park in the sky and incorporates NbS into the design.

[27] www.nationaltrust.org.uk – Europe's largest conservation organisation

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10.5 Regional Impact

In 2019, Greater Manchester Combined Authority (GMCA) secured funding for the complimentary EC Urban Innovative Actions (UIA) IGNITION Project. IGNITION (Oct 2019 - April 2022) developed innovative financing solutions for investment in Greater Manchester's natural environment. This investment has helped to build the city region's ability to adapt to the increasingly extreme impacts of climate change.

The initiative funded €4.5 million to bring together 12 partners from local government, universities, NGOs and business. The aim was to develop the first model of its kind to enable major investment in large-scale environmental projects which can increase climate resilience.

IGNITION used GrowGreen to contribute to the body of knowledge on business cases for NbS and has built a Living Lab at the University of Salford (UoS). Both MCC and UNIMAN were partners, facilitating the exchange of information, monitoring and evaluation. This has produced a central evidence repository of existing and emerging evidence. The IGNITION nature-based solutions evidence base and supporting documents are available to download.

10.6 National Context

GrowGreen provides significant supporting evidence and approaches that reflect positively the challenges and opportunities presented by new UK governmental legislation.

The Environment Act 2021 (England and Wales) - Following the decision for the UK to leave the European Union, the UK government has now resumed complete responsibility for domestic environmental law and policy for the first time in decades. The new act is a once in a generation opportunity to seek to protect the environment and set a course for nature recovery in the UK. It will seek to create a new governance framework for the environment, and act as an enabler for priorities set out in Defra's[28] 25 year Environment Plan with a pivotal role in the UK's aim to achieve net zero carbon emissions by 2050.

Defra's 25 Year Environment Plan is the mechanism to deliver the ambitions set out in the Environment Act. Objective headings include prioritising action supporting:

1. Clean air
2. Clean and plentiful water
3. Thriving plants and wildlife
4. Reducing the risks of harm from environmental hazards
5. Using resources from nature more sustainably and efficiently
6. Enhancing beauty, heritage and engagement with the natural environment
7. Mitigating and adapting to climate change
8. Minimising waste
9. Managing exposure to chemicals
10. Enhancing biosecurity

Biodiversity Net Gain is an output of the new act and it is becoming a legal requirement that any impact on biodiversity resulting from a new development, where it cannot be avoided, will not only be compensated, but will have to demonstrate a 10% biodiversity net gain, a legal commitment to

[28] The Department for Environment, Food and Rural Affairs (Defra) is the government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities in the United Kingdom of Great Britain and Northern Ireland

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improve biodiversity on development initiatives. Conservation covenants between landowners and responsible bodies will be established, to provide sustainable and effective management for a minimum of thirty years.

Nature Recovery Networks (NRN) will be a national network of wildlife rich places. The government's aim is to expand, improve and connect these places across our towns, cities and countryside. The NRN is a commitment in the government's 25 Year environment plan and part of the forthcoming nature strategy. Informed by GrowGreen, Manchester is developing its own nature recovery network by delivering a new Manchester Biodiversity Strategy in 2022.

11 Future Research

The GrowGreen Project has been successful in providing an evidence base for NbS impacts, Living Lab and has already been replicated in the city. It has opened up other avenues for further research:

- A future study could investigate temperature dynamics and microclimates once the vegetation / trees of the community park have been fully established. Reductions in UHII are most pronounced when vegetation / trees are mature.
- The work focused on tree and vegetation biodiversity could encourage further research into the enhancement of local wildlife.
- The Park has increased the connectivity of the greenspace in the local neighbourhood, thus improving wildlife corridors. The Park has yielded significant increases in residents using the park. This data has been collected using a human-based observation approach. Automated techniques using cameras and associated software could capture more accurate information on park usage and activity.
- A key benefit of NbS is carbon storage and sequestration. Further work could investigate the carbon cycle, covering the stocks and flows of carbon with the community park.
- The water quality investigations reveal that contaminated road runoff (heavy metals and road salt) is delivered to the planted areas of the Park. Although the vegetation within the NbS features has thrived over the last two years, the water quality investigation does still raise a number of questions, including how does this contaminated runoff impact soil condition and long-term heavy metal loading; and does extreme events of contaminated runoff impact plant health – such as an oil spill. As part of the research work at the UNIMAN, these questions are being investigated through MSc work, where contaminated road runoff is added to mesocosms to assess plant health and functioning.
- Test the concept of blended neighbourhood funding models where residents, health care provider, councils and water companies all contribute to the investment in NbS.

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12 Appendices

12.1 Appendix I - Planting Schemes

Woodland

- Many of the existing mature trees such as the Salix babylonica (Weeping Willow), Acer platanoides (Norway Maple) and Tilia x europaea (Common Lime) were retained, with some having been crown lifted and pruned to improve their visual form and structure.
- The understory has been planted with a mix of bulbs and native shrubs which suit the woodland floor setting, which also provides a habitat and refuge for birds and animals and foraging opportunities for small mammals.
- Bulbs suited for sunnier conditions have been planted in naturalistic swathes in the areas of open grass. The rain garden has been planted with a wide range of species to create a densely vegetated and thriving planting bed that can withstand periods of occasional flooding.
- The planting in the rain garden includes Vinca minor (Periwinkle), Iris pseudocorus (Flag Iris/Water Iris), Rudbeckia hirta (Black-eye Susan), Molinia caerulea (Purple Moor Grass), and Miscanthus sinensis (Chinese Silver Grass). All the plants in the rain garden have been selected for their growing ability to withstand both arid and wet conditions as they would need to respond to hotter drier summers as well as period of heavy rainfall. Bulbs include Tulipa (Tulips), Narcissus (Daffodils) and Galanthus (Snowdrops).
- Shrub planting includes Hebe (Hebe), Carex (Sedge) and Bergenia (Elephant's ears) which have been planted across the site. Tree planting includes Alnus glutinosa (Common Alder), planted in the bioretention tree pits, and Betula pendula (Silver birch), Prunus umineko (Oshima Fuji Cherry) and Sorbus 'Joseph Rock' (Mountain Ash) planted in areas that are less damp.

Meadow

- The planting in the picnic area is enclosed by colourful low-level planting, orchard trees and a native hedgerow. The wildflower and perennial species provide planting interest all year round.
- The tree planting includes Alnus glutinosa (Common Alder), Betula utilis jacquemontii (Himalayan Birch), and Prunus avium 'Plena' (Bird Cherry). Plants in the swale includes Iris pseudocorus (Flag Iris/Water Iris), Mentha aquatica (Water Mint), Lythrum salicaria (Purple Loosestrife), Osumunda regalis (Royal Fern) and Glyceria maxima (Reed Manna Grass).
- The hedge species includes native species such as Fagus sylvatica (Common Beech), Rosa rugosa (Rugosa Rose) Ligustrum ovalifolium (Common Privet), Ribes nigrum (Blackcurrant) and Lavandula angustifolia (English Lavender).

Community Plaza

- Ornamental perennials and grasses include sensory planting with tactile qualities, and plants with scented flowers and leaves. The planting in the swale and raingardens have been selected to include species able to tolerate both periods of drought and wet weather conditions.

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- The tree planting includes an Alnus glutinosa (Common Alder) planted in the bioretention tree pit, and a number of Liquidamber styraciflua (Sweet Gum Tree), Malus Evereste, Malus Rudolph, (Apple trees)and Pyrus caleryana 'Chanticleer' (Ornamental pear trees) planted across the site.
- Shrubs include Thymus vulgaris (Common Thyme), Hebe (Hebe variety) and Lavandula angustifolia (English Lavender), bulbs include Tulipa (Tulips), Narcissus (Daffodils) and Allium (Chives).
- The raingarden planting includes, Aster thomsonii (Michelmas Daisy), Bergenia sp (Elephant's Ears), Dryopteris felix-mas (Male Fern), Hosta sp (Plantain Lily) and Iris laevigata (Water Iris).

12.2 Appendix II – Awards and Videos

Awards

- Design Council's 'Golden Pineapple' Award for Best Public Space: The Pineapples awards are unique in seeking to celebrate great places that thrive, where people want to live, work, play, shop or learn. www.festivalofplace.co.uk/project-showcase/winners-gallery-the-pineapples/west-gorton-community-park-manchester-winner--manchester-city-council-with-bdp

- Excellence in Flood and Water Management Award from the Landscape Institute Awards 2021 (BDP: West Gorton Community Park designers): www.youtube.com/watch?v=Rn2cwEe6opc

- Excellence in Flood and Water Management Award from the Landscape Institute Awards 2021

Videos

- A Park that Drinks Water https://www.manchesterclimateready.com/mcr-initiatives/gorton-climate-resilient-sponge-park (includes build footage)

- BDP: West Gorton Community Park designers: www.youtube.com/watch?v=Rn2cwEe6opc

- Seeing Is Believing: West Gorton Community Park (Groundwork) www.youtube.com/watch?v=-QYGT0LVRUI

- West Gorton Community Park (Shortened version- Groundwork) www.youtube.com/watch?v=NiX8SQ_zsPk

- West Gorton Community Park (As show at GrowGreen Final Event Brest November 2022) www.youtube.com/watch?v=YNNlEi7hAiM

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