



EUROPEAN UNION



EU MISSIONS

ADAPTATION TO CLIMATE CHANGE



November 2024

Grey to Green Street Design

Enabling Climate Change Adaptation through Sustainable Drainage Systems in Sheffield, UK

Sheffield's Grey to Green Strategy enabled Climate Change Adaptation by transforming a large inner-city road into a public green space. At the project's core is a sustainable urban drainage system connecting the city with the rivers and contributing to flood protection.

Key Learnings

- **Information resolved oppositions:** As the project aimed to narrow parts of the “redundant” highway, local businesses were concerned about being less accessible for customers. Modelling the new road arrangements as well as demonstrating the added benefits for the businesses enabled to resolve this initial opposition and to win the argument.
- **Flexibility for successful implementation:** Despite initial site investigations, surprises during the construction phase required flexibility from the design team. It was necessary to incorporate changes in the implementation due to, for example, a very high voltage cable.
- **Active and committed client involvement from feasibility to post-completion:** The project team engaged the city at key consultation stages, from securing funding to submitting claims and achieving targeted outcomes. After project completion, the city maintained ongoing engagement with stakeholders and organisations interested in learning more about the grey-to-green initiative.

About the region

Sheffield is located in the central part of England, South Yorkshire, about 260km (160 miles) northwest of London. The city covers an area of about 122 km². According to the latest census from March 2021, Sheffield has a population of 556,500 individuals ([2022](#)). In 2023, the mean temperature was 1,2 °C warmer than on average ([1979-2023](#)). The mean average precipitation is also increasing.

Climate Hazards

Flooding

Sector

Buildings, Water Management, Urban

Key system

Ecosystem and Nature-based Solutions, Water Management



Figure 1: Map of Sheffield. Image Credit: [britannica.com](https://www.britannica.com).

Climate Threats

Sheffield is threatened by unpredictable and extreme weather, increased flood risk, hotter, drier summers, and warmer and wetter winters. In 2023, temperatures recorded in Sheffield reached 39.4°C. Climate-induced floods pose a particular threat to Sheffield due to its location adjacent to rivers and streams.

Over the last 20 years, Sheffield has been struck by four heavy rain events, one of which caused three deaths and the evacuation of 1,000 inhabitants in 2007. Also, in 2019, 70mm of rain fell within 24 hours, which caused impassable roads and almost flooded the Don River. In autumn 2023, heavy rain events also occurred.

To reduce the risks posed by climate change, the city council has established a [Ten Point Plan for Climate Action](#), including the internationally acclaimed [Grey to Green Strategy](#). The plan focuses on three key issues, one of which is the response to the risk of flooding.

Grey to Green for Climate Change Adaptation

Sheffield's City Council, together with landscape architects, sustainable urban design specialists, and ecological management companies, implemented the climate change adaptation strategy, which incorporates Nature-based Solutions for flood prevention, including a sustainable urban drainage system, as a response to the impacts of the flooding events.

The Grey to Green project is the UK's longest "green street" corridor and the largest locally adapted sustainable urban drainage system. The sustainable drainage system has replaced roads with cycle paths and has drought-resistant, pollen-rich planting to capture water for flood prevention. It is adjacent to the River Don, one of the city's flood-prone areas. One of the main functions of the sustainable urban drainage system is to reduce and slow down surface water runoff from roads and pavements. By mimicking natural

processes, the sustainable urban drainage system absorb rainwater and return it to the rivers. The rainwater runoff flows into the drainage ditches and rain gardens, as depicted in Figure 2. **Error! Reference source not found.** The installations contribute to cleaning the water from pollutants, promoting infiltration and evapotranspiration, and watering the plants in the facilities.

The check dams, depicted below in the diagram (Figure 2), allow the so-called “cells” to fill with rainwater during extreme events and overflow to the next cell. The installations contribute to reducing the flood risk as they have a sponge function and better distribute the excess water.

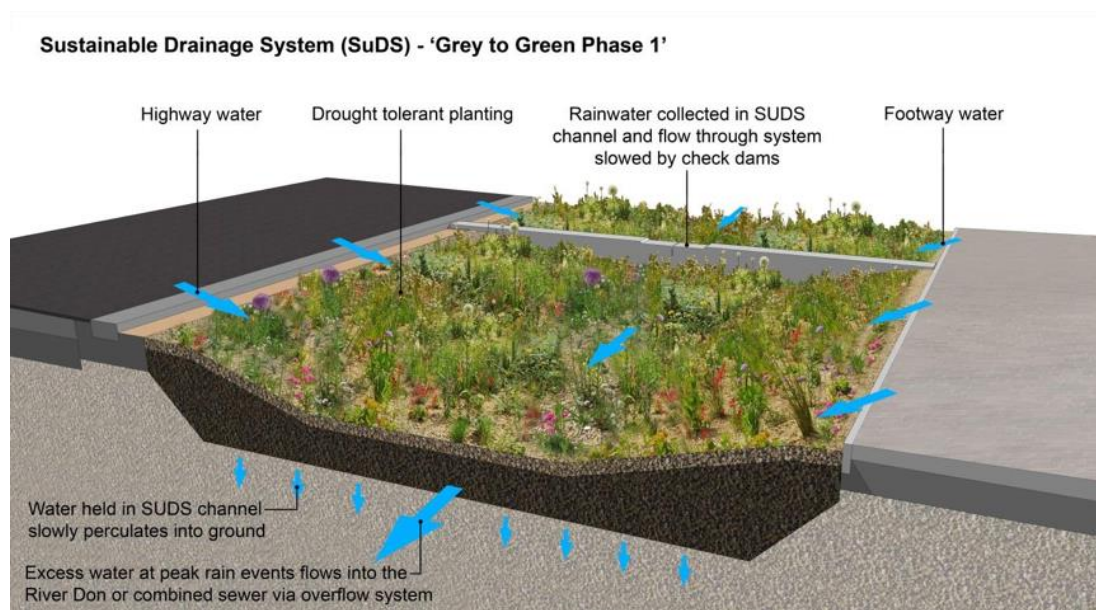


Figure 2: Visualisation of the sustainable urban drainage system in Sheffield. Image Credit: Sheffield City Council.

With their bio-infiltration capacities, shallow drainage ditches and rain gardens allow the water to fill them temporarily and slowly release it into the soil or atmosphere. Models of different weather events show that the sustainable urban drainage system can significantly reduce the amount of water running off during a typical heavy rainfall event (such as one that occurs once every 30 years). In a more extreme event (like one that happens once every 100 years), the system may cause some overflow, but it still helps to greatly reduce the runoff, protecting roads and sidewalks from damage. The system is designed to release a controlled amount of water into the river during such events, minimising potential flooding.

The engineered soils used for the drainage ditches and rain gardens are made from recycled compost and glass mixed with crushed sandstone and low proportions of loam. Engineered soils have multiple benefits, such as higher infiltration rates than conventional soils, allowing the water to percolate into the ground more effectively. The filtration properties of those soils help remove pollutants and sediment from the stormwater, through which the water quality is improved during the infiltration process. This also shows that climate change adaptation measures can contribute to a circular economy and mitigate the human impact on our planetary system. Locally sourced and recycled materials formed the basis for a modified conventional green roof substrate type.

- **Bio-infiltration** uses plants and soil to filter and absorb rainwater, helping it seep into the ground naturally.
- **Shallow drainage ditches** are small, shallow channels that guide rainwater away from certain areas to reduce flooding.
- **Rain gardens** are specially designed with plants absorbing rainwater from surfaces like roofs or driveways, reducing runoff.
- **Engineered soil materials** are man-made soil mixtures to improve drainage and support plant growth, used in green infrastructure like rain gardens.

Engineered soil materials

The substrate comprises:

- 70% crushed sandstone aggregated from a local quarry, promoting the drainage capacity and giving the substrate volume and solidity.
- 20% composted green waste from Sheffield, containing nutrients slowly released to the plants. The compost retains water for plant growth, improves soil structure and promotes microbiota for healthy soils.
- 10% sandy slit loam is also essential for promoting nutrient availability and providing the optimum soil structure.

Two building phases

The project was implemented in two building phases: the first was approved in 2014 and completed in 2016, and the second was approved in 2019 and completed in 2022. Figure 3 depicts the grey-to-green building phases and their locations. In total, 1.3 kilometres were converted into climate-adapted streets.

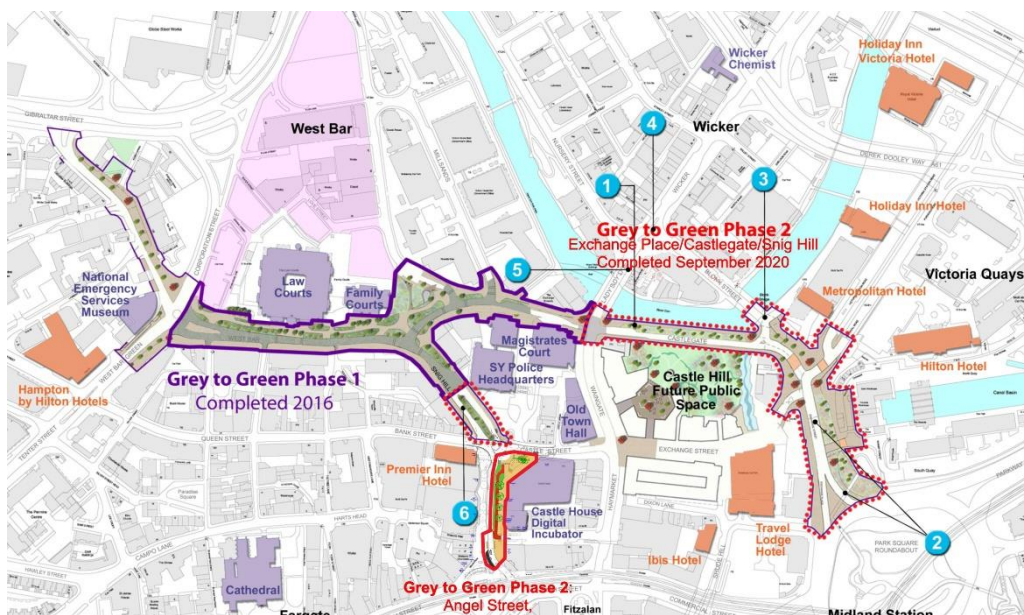


Figure 3: Building phases of the Grey to Green Strategy. Image Credit: [sheffield.gov.uk](https://www.sheffield.gov.uk).

Before the site was developed, redundant, unattractive roads and complex junctions dominated this part of the city. The place was physically cut off from the rest of the city, which kept people and investments away.

Stakeholder engagement

The project team consulted local entrepreneurs and residents through meetings and public exhibitions — the consultations aimed at gathering the views of the locals. Regular meetings with the Riverside Business Association were also scheduled to address the difficulties that arose during the construction phase. The businesses, for example, were concerned about being less accessible for customers but modelling the

new road arrangements and demonstrating the benefits for the businesses resolved initial oppositions. The landscape architecture students at Sheffield University took on a crucial role in designing the rain gardens, and drainage ditches, and a university professor from the Landscape Department at Sheffield University supported perennial planting with his expertise.

Involving a social enterprise for long-term maintenance

Even though another contractor usually provides street plant maintenance in Sheffield, it was possible to negotiate an exception for Grey to Green. In this case, [Green Estate Ltd](#), a local social enterprise, was hired for the first three years to provide the planting maintenance. This company specialises in innovative landscape management and works closely with Sheffield University. Green Estate is a Community Interest Company that engages with volunteers to establish climate-resilient (urban) landscapes. The design principles implemented contributed to giving the area identity and reducing maintenance costs for the Sheffield City Council.

Multiple benefits provided by Nature-based Solutions

Besides contributing to Sheffield's climate change adaptation strategy, the Grey to Green project establishes a sustainable urban drainage system and surface water management. The multifunctional project aims to increase urban biodiversity and create a wildlife corridor. Multi-layered planting fosters human well-being by protecting pedestrians from air pollution and trees, which contribute to reducing the urban heat island effect. Compared to the rest of the city centre, the project area was less economically strong. However, the climate change adaptation measures also resulted in economic developments, attracting companies to rent offices and residents to move to the area. This shows that climate change adaptation measures in landscape architecture contribute to climate resilience, enhance the spatial quality for users, and catalyse inward investments in an area.

"Through Grey to Green, we are bringing climate resilience, colour, and economic investment to inner-city Sheffield. It was designed with climate change, wellbeing and economic investment in mind and demonstrates that this sort of liveable, sustainable city development should be the template for successful city renewal."

Councillor Terry Fox, Leader of Sheffield City Council

The Grey to Green project was awarded a National Green Champion Award for environmental best practices in the construction category as part of the Green Apple Awards. Furthermore, the project won two Yorkshire in Bloom awards, the Gold Standard and Best Environmental Project in Yorkshire 2016, and the Sheffield Design Awards for Best Open Space and Overall Outstanding Project Award 2016.



Figure 4: Nature-based Solutions for Climate Change Adaptation in Sheffield. Image Credit: [Nigel Dunnett](#).

Financing

The project was financed by the Sheffield City Region Investment Fund (now South Yorkshire Mayoral Combined Authority), the European Union Regional Development Fund (ERDF) programme, and the Sheffield City Council, with small contributions from the Canal and Rivers Trust and Yorkshire Water. The first phase cost about £3.6 million (€4.3 million), and the second phase cost around £6.3 million (€7.5 million).

Summary

As part of the Ten Point Plan, the Sheffield Grey to Green project demonstrates how state-of-the-art landscape architecture can successfully contribute to climate change adaptation for increasing resilience toward flooding in urban areas and providing Sheffield's citizens with multiple benefits. The sustainable urban drainage system with drainage ditches and rain gardens ensures successful water management and flood protection. Stakeholder engagement and transparent communication support implementation and reduce potential conflicts. The thought-through design also reduces long-term maintenance costs for the city council.

Further information

- <https://www.uk100.org/projects/knowledgehub/grey-green-mitigating-flood-risk-and-regenerating-sheffields-city-centre>
- <https://www.nigeldunnett.com/grey-to-green-2/>
- <https://robertbrayassociates.co.uk/>
- <https://greenestate.org.uk/>
- <https://www.greytogreen.org.uk/background>
- <https://www.welcometosheffield.co.uk/content/attractions/grey-to-green/>

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