February 2025

Permeable Paving for Housing
Lamb Drove & Riverside Court

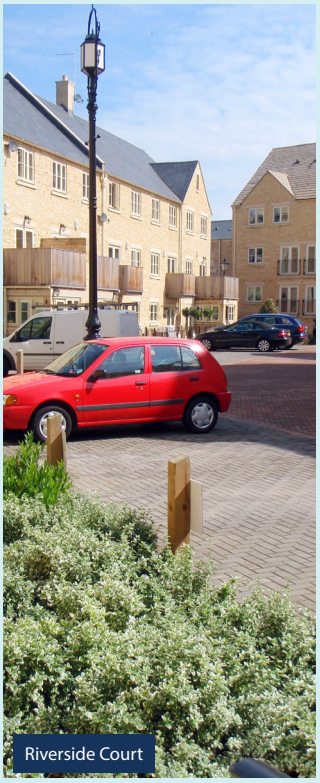
Case studies demonstrating the key role of concrete block permeable paving for efficient and cost-effective SuDS on housing developments.

Mineral Products Association

Introduction

Our first case study – Lamb Drove – is particularly important as a SuDS Monitoring Project. It confirms the durability of concrete block permeable paving (CBPP) and is cited as an exemplar in Defra's January 2023 report *'The review for implementation of Schedule 3 to The Flood and Water Management Act 2010'*. Completed in 2006, it was one of the first housing projects in England with integrated sustainable drainage (SuDS) and is still performing well today. Completed around the same time and also performing well, our second case study – Riverside Court – demonstrates that CBPP enables effective SuDS for high-density urban housing as well.

Importantly, wider use and adoption of CBPP will enable developers and local authorities to meet government demands to replace impermeable surfaces in both new developments and existing settings. These requirements were highlighted in the 2022 National Infrastructure Commission report on surface water flooding and 2023 Defra report launching mandatory SuDS for England.



Riverside Court

Understanding Permeable Paving

With more than 25 years' use on a wide range of project typologies, including housing, adopted roads and even container terminals, concrete block permeable paving (CBPP) has proven to be a robust, resilient and adaptable technology. It provides an attractive, safe and puddle-free surface for pedestrians and traffic, combining a structural pavement with integral drainage and no gullies. With the latest innovations CBPP can be used to help deliver low-cost SuDS for housing and other developments with other benefits including sustenance for street trees.

The key to CBPP is its permeable surface zone of high-strength concrete blocks with angular aggregate used to fill enlarged joints and as a laying course. It allows water to pass between the blocks while filtering out silt with many pollutants – particularly the 'first flush' following rainfall – and preventing ingress of debris, retained on the surface where it can easily be removed. It can then deliver a gradual flow of clean water for safe SuDS, irrigation, biodiversity, reuse or discharge.

This unique permeable surface works in conjunction with various construction profiles and differentiates the technology from other types of 'pervious' paving. In most CBPP constructed to date, water passes from the surface zone into voids within an underlying coarse grade aggregate permeable sub-base, combining structural support and water storage. Increasingly, however, alternative structural layers are being used to create exciting opportunities for urban trees and green infrastructure, provide additional water storage, accommodate statutory services or meet other requirements.

More information is available in the *'Understanding Permeable Paving'* guide available at www.mpaprecast.org

Lamb Drove

The Lamb Drove SuDS Monitoring project in Cambourne, Cambridgeshire – designed by Robert Bray Associates – is important for a number of reasons. Despite the modest size of the site, it demonstrates the use of as many SuDS techniques as possible, including concrete block permeable paving, used in combination with other elements to form an effective management train.

Despite being retro-fitted to a conventional housing layout, the SuDS are fully integrated with the landscape and have proved to be effective in managing rainfall as well as popular with residents.

Perhaps most importantly, it demonstrates that SuDS work and should cost less than conventional piped drainage in terms of construction, maintenance and whole-life costs. It also highlights the robust performance of concrete block permeable paving with minimal maintenance requirements – and lower whole-life costs.

Background

Completed in 2006, Lamb Drove was selected as a SuDS Showcase project within the FLOWS (Living with Flood Risk in a Changing Climate) programme funded by the European Regional Development Fund (ERDF). Cambridgeshire County Council subsequently commissioned Royal HaskoningDHV to carry out a SuDS monitoring project from 2008 to 2011, measuring the performance of the SuDS over time.

This research aimed to assess the outcomes of using various SuDS techniques in a management train, compared with those of a conventional piped drainage system nearby.

This case study includes photos taken during site visits in 2012 and 2018 (6 and 12 years after completion, respectively)

Context

Cambourne is a settlement located on high ground and its surface water runoff contributes to a watercourse that has caused flooding to nearby villages. By agreement with the Environment Agency, runoff from Cambourne is limited to the greenfield rate of 2 l/s/hectare (development area).

The Lamb Drove 'Study Site' is around one hectare and contains 35 dwellings owned and managed by CHS Group. It has been compared with a conventionally drained 'Control Site' that is similar in size, density and location.

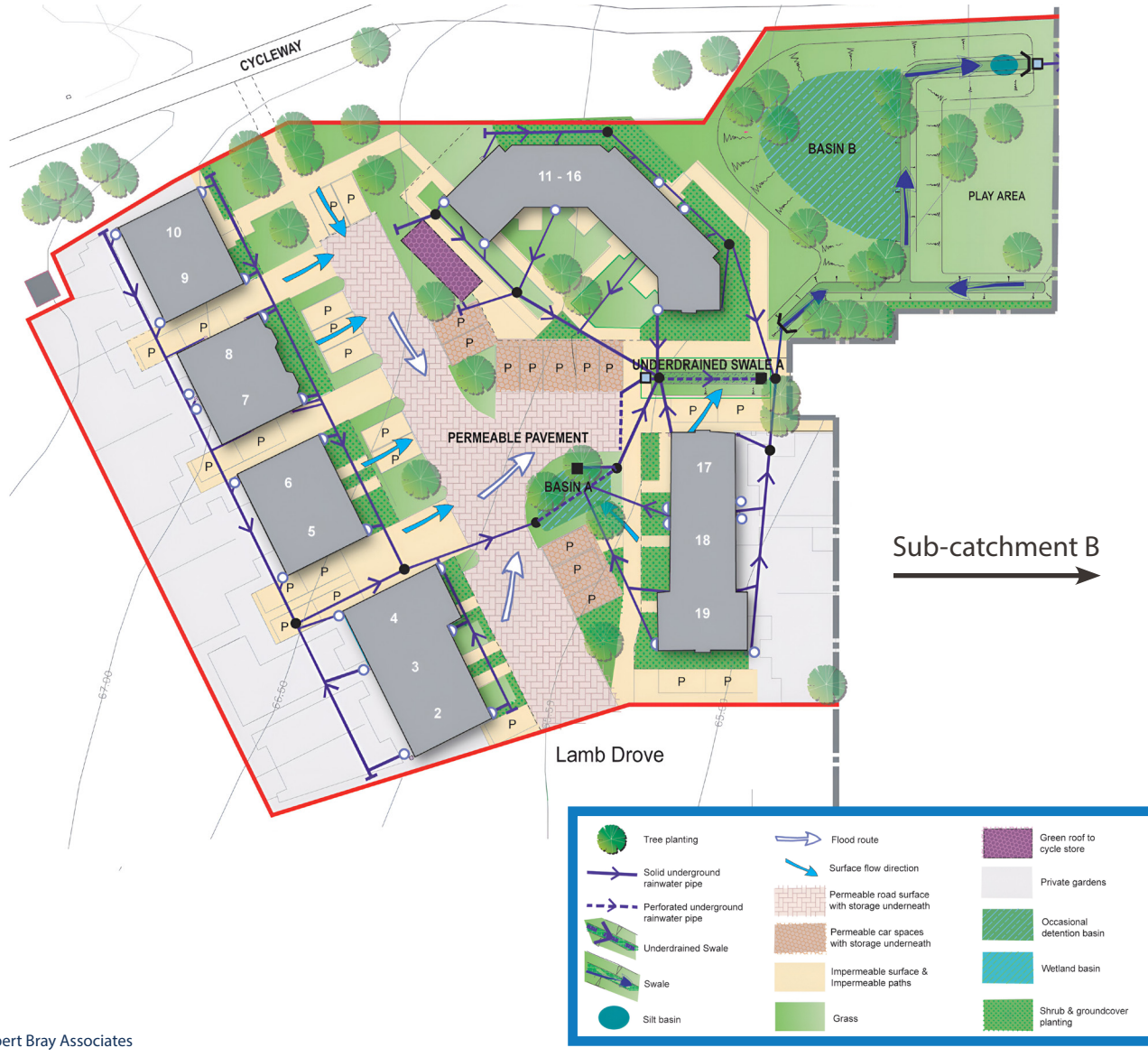
The Lamb Drove site slopes down from north-west to southeast and is bounded by a public footpath to the north and a proposed golf course to the east. Ground conditions are largely impermeable clay.

SuDS Design

The SuDS scheme was designed by Royal HaskoningDHV with Robert Bray Associates and applied to an existing, conventional housing layout based around two cul-desacs. Two SuDS management trains serve distinct subcatchments A and B (shown in separate site plans), incorporating the following SuDS techniques:

- Concrete block permeable pavements
- Water butts
- Green roof
- Swales
- Filter strips
- Underdrained swales
- Detention basins
- Retention pond.

Sub-catchment A Site Plan



Design Constraints

Despite the spatial constraints of applying SuDS to a previously designed conventional housing layout, natural flow routes have been optimised through the site for low and high flows, as well as for exceedance. SuDS have been integrated with landscape design adding amenity, interest and biodiversity to an otherwise unremarkable scheme, and a holistic approach taken with the design.

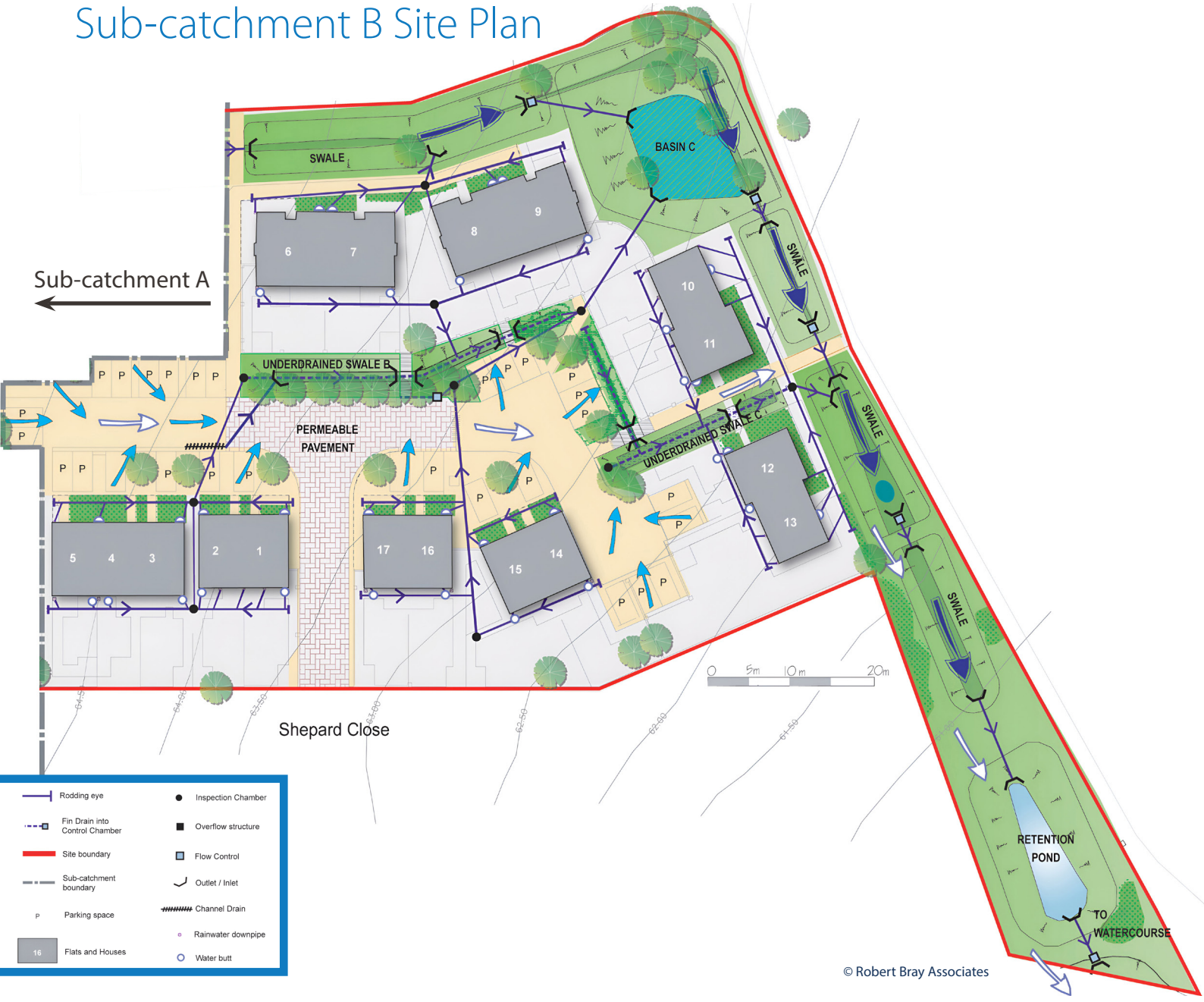
Underdrained swales have been used for dry surfaces near homes while swales elsewhere provide opportunities for wildlife.

Concrete Block Permeable Paving

Concrete block permeable paving was chosen as a SuDS source control and robust pervious surface for the two distinct access roads. It collects, cleans and stores the most polluted runoff from the site. There is a flow control on each of the two permeable paved access roads to optimise water storage, reducing the need for additional storage further down the site.

Although other case studies have demonstrated the potential for permeable paving to accept roof water directly, it was previously agreed that roofs would drain via conventional piped drainage directly to on-site swales and basins. However, impermeable areas, such as driveways, simply discharge onto the concrete block permeable paving.

Sub-catchment B Site Plan



The Designer's Perspective

Bob Bray of Robert Bray Associates discusses the SuDS design at Lamb Drove.

The FLOWS Project at Lamb Drove provided a unique opportunity to demonstrate the principles and practice of SuDS on a relatively common type of housing layout, with a dwelling density of 35 houses per hectare. The SuDS design was unusual for its time and is still an exemplar in that runoff is collected at, or brought to, the surface before flowing naturally as a temporary stream through the development.

Source control – using concrete block permeable paving and underdrained swales – proved essential to ensure that only clean water reaches surface SuDS features, including amenity space and wildlife areas. Pipes have only been used as short connections between SuDS features, not as the main conveyance system for runoff. The shallow depth outlets from permeable paving enable shallow SuDS basins that sit comfortably in the landscape, are easy to access and actually used by the community - in contrast with steep-sided, deep detention basins.

Underdrained swales pass between homes and are kept in good order with simple maintenance. Some also provide exceedance routes to open space beyond.

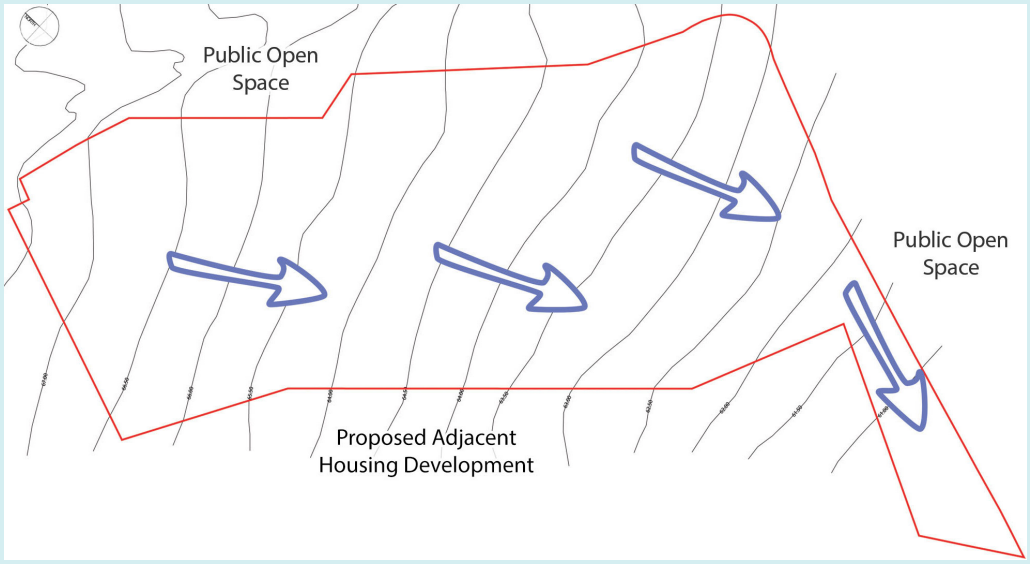
Although the basic layout had been previously agreed for planning purposes, it was still possible to design two rainwater sub-catchments, each with a sequence of SuDS techniques in series to form 'management trains'. These everyday flow routes through the development were supplemented by overflow routes and exceedance pathways to protect the community in the event of blockage or exceptional rainfall events.

As water travels through the development it is important that it can pass slowly from one SuDS feature to the next. This slow flow requires different inlet and outlet designs, that allow flow control mechanisms where necessary, and an overflow or exceedance route for very high flows. Our design involved protection of the inlet and outlet with a steel basket filled with stone. This simple device prevents blockage by large floating debris, such as plastic bags and leaves, and has now been used on many sites without report of blockage.

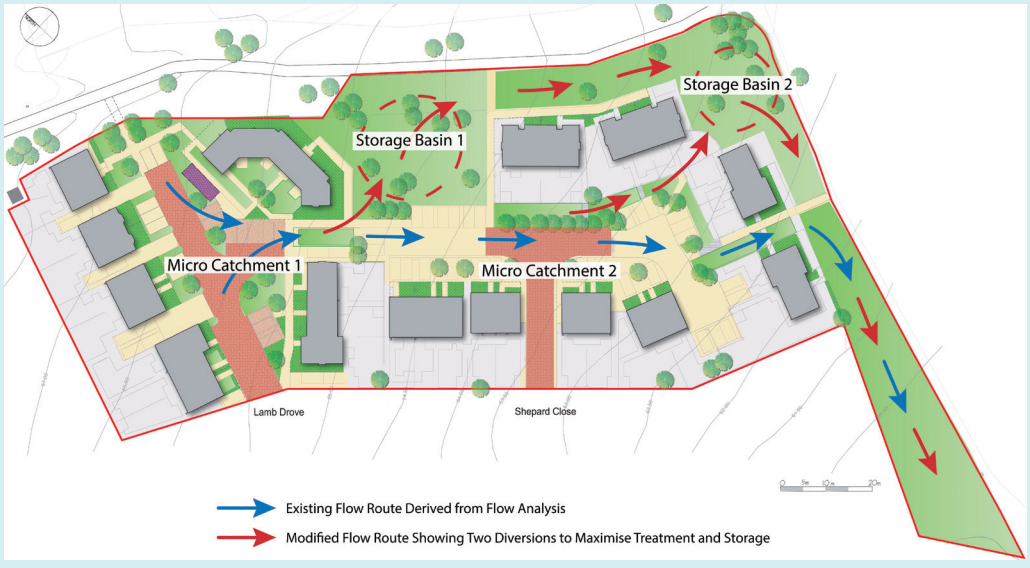
It was possible to integrate all the SuDS components into a coherent landscape design so that residents can understand how the system works and site management is obvious, simple and cost effective. The idea of 'passive maintenance' assumes most care required for the SuDS is general site maintenance, including litter collection, grass cutting and sweeping of hard surfaces. Inspection and cleaning of inlets, outlets and flow controls remains the only dedicated SuDS management.

The monitoring exercise is the most thorough undertaken in the UK to date and confirms not only that the SuDS manage flows, volumes and water quality effectively but also that residents like the SuDS environment as it slowly matures into the future. Considering that the SuDS at Lamb Drove demonstrate a 10% cost saving over conventional piped drainage, are simple and cost effective to maintain and that the enhanced performance has been confirmed by 3 years of detailed monitoring, it is surprising that the SuDS approach has been so long in gaining general acceptance in the development community.

The FLOWS at Lamb Drove before the addition of the SuDS scheme.



A flow route analysis was performed to understand how water would naturally behave on the undeveloped site



Two Micro Catchments gather and store water before it passes through additonal SuDS features to Storage Basins situated along a new modified flow route.

Permeable Paving Over Time

The Monitoring Report confirms that only limited manual sweeping of the permeable paving has taken place – less than originally specified. In addition, it was noted that a part of the pavement may have been heavily mechanically cleaned by a road sweeper in error. It is important to exclude permeable paving from inappropriate operations that remove the 2/6.3mm aggregate jointing material.

Nonetheless the Monitoring Report concludes that:
"The permeable pavement infiltration study specifically illustrates the robustness of the performance of this feature to limited maintenance. The infiltration capacity of the permeable pavement is able to adequately cope with the highest recorded rainfall intensity at the Study Site."

Monitoring of pollutants, biodiversity and resident satisfaction is testament to concrete block permeable paving delivering a gradual flow of treated water to open SuDS features further down the management train.

Concrete block permeable paved carriageway in Catchment A, accepting runoff from conventional block paved drives and parking areas. Concrete kerbs laid flat delineate road edges.

" Source control – using concrete block permeable paving and underdrained swales – proved essential to ensure that only clean water reaches surface SuDS features, including amenity space and wildlife areas "

Conventional block paved road, driveways and parking areas in Catchment B all drain onto the permeable paved central carriageway.

SuDS Over Time

An Environment Agency requirement of 2 l/s/hectare has been achieved locally using open space for the enjoyment of residents and without recourse to additional measures. The project demonstrates the real value of integrating SuDS with public open space and their capabilities to deliver a controlled flow of clean water at lower costs.

The SuDS design at Lamb Drove was designed to be easily looked after and generally as part of everyday site maintenance. Most of the work required can therefore be considered as site care rather than dedicated SuDS maintenance.

Water is retained in Basin B, a landscaped area for amenity and wildlife. Residents and visitors are informed about the SuDS scheme and how it works by a graphic still in place today.

Wildflower meadow planting, prior to annual cut and removal of vegetation to 'wildlife piles'.


2018


2011


2018

The Monitoring Control Site

Friar Way is a similar size, density and layout to the nearby Study Site, Lamb Drove. It is served by a central access road with two lateral parking courtyards, all paved with impervious materials. A 'country footpath' bounding two sides of the site provides the only soft landscape and tree planting. Within the site, public space is ill-defined and of little amenity value, particularly the two unloved 'courtyards' used for sporadic car parking and inappropriate material storage.

All hard surfaces drain into numerous gulleys, piped directly to main drains. This arrangement provides no water attenuation or storage, or removal of pollutants from runoff. The development is a clear illustration of missing an opportunity to introduce multi-functional SuDS, particularly bearing in mind cost savings, as outlined in *BS8582:2013, Code of practice for surface water management of development sites* and *The SuDS Manual (2015)*, as confirmed by the Monitoring Report.

The access road is characterised by continuous asphalt surfaces, served by numerous road gulleys discharging directly to piped drainage.

The impermeable block-paved courtyards offer negligible amenity value and no green space – a missed opportunity for SuDS.

Monitoring Report Conclusions

Comparing Costs

Overall, both capital and maintenance costs – and therefore whole-of-life costs – associated with the Study Site were much lower than those for the conventional piped drainage system Control Site. The Monitoring Report noted capital cost savings of £314 per home and also suggested 20 – 25% lower maintenance costs than traditional drainage on the Control Site. Having said that, further cost savings are unaccounted for in these cost comparisons, as follows.
The SuDS at Lamb Drove achieve 100% of the required flow rate reduction by providing attenuation storage within the site and the immediately adjoining greenway land. This represents a saving as there is no reliance on strategic balancing lakes, which have associated capital costs, maintenance and land take requirements. Also, Lamb Drove SuDS do not connect to the adopted public sewer and therefore avoid any connection and annual charges for storm water disposal.

Rather than retrofitting, integration of SuDS holistically within the scheme design from the start would have produced further savings, as would a wider SuDS strategy for the whole Cambourne development. Some additional SuDS features were also included for demonstration purposes, not out of necessity.

Summary of Findings

Quantity - The Study Site has attenuated surface water flows and significantly reduced peak flows have been observed when compared with the Control Site, as shown (top graph). The monitoring programme has clearly shown the successive attenuation and reduction of both flow and volume through each stage of the SuDS management train.

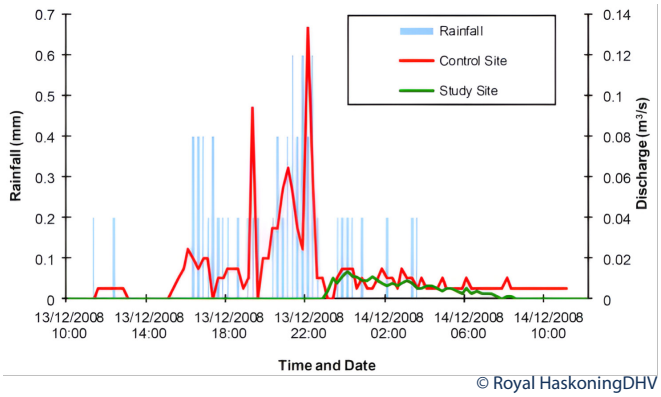
Quality - The SuDS system has improved the quality of water discharged from the Study Site when compared with the Control Site, for example as shown (bottom graph). Results have shown that the Study Site has seen reductions in concentrations of a variety of pollutants and other water quality indicators.

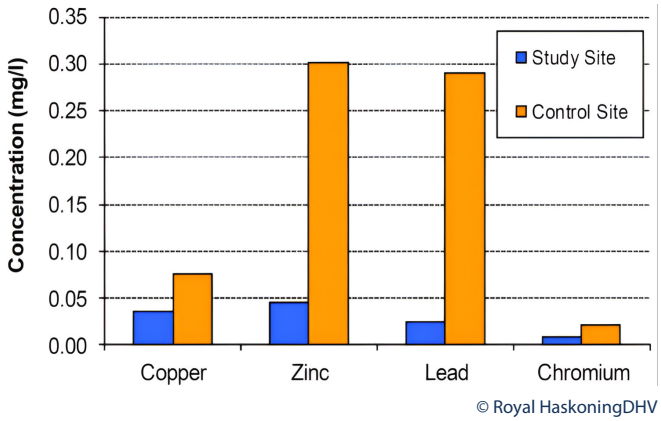
Biodiversity - The Study Site has shown a higher number and diversity of species present over the three habitat surveys than the Control Site. The Study Site represents a more natural management regime and this is represented in the range of species present on the site.

Amenity - The residents surveys found that they regard the open space around their homes as more pleasing when compared with others parts of Cambourne. It is apparent that the residents of the Study Site have a high regard for the open spaces within the SuDS scheme. This is in line with findings from some other SuDS sites, where the positive impact on the immediate areas had transformed into locally higher property values.

Concrete Block Permeable Paving - The permeable pavement infiltration study specifically illustrates the robustness of the performance of this feature to limited maintenance. The infiltration capacity of the permeable pavement is able to adequately cope with the highest recorded rainfall intensity at the Study Site.

Concrete block permeable paving some 13 years after completion.





Riverside Court

This high-density (104 units per hectare) town-centre housing scheme in Stamford, Lincolnshire takes a similar approach to Lamb Drove and was also designed by Robert Bray Associates. Here, green space is limited and most public areas between buildings are concrete block permeable paving (CBPP) which collects, cleans and conveys water slowly to other SuDS features. The CBPP also accepts runoff from other adjacent hard areas and roofs, and continues to operate well following only surface sweeping maintenance since completion in 2005.

Stored, treated water passes from the CBPP directly into planted rills and canals, before any remaining flows pass into the nearby River Welland. The rills and canals with safe stepped access add interest and much-needed greenery to the courtyard environment. Flow control chambers ensure a gradual flow of clean water throughout the site and into the river under all conditions. This nature-based design with CBPP enables 'source control' with amenity and biodiversity benefits along the SuDS management train.

Riverside Court Site Plan

On this high-density scheme most public areas between buildings are permeable paving.

Flow control chambers ensure a gradual flow of clean water into the River Welland under all conditions.

Planted canals with safe stepped access receive clean water from permeable paving.

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