

A Holistic hard and soft SUDS system used in the creation of a Sustainable Urban Village Community

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ABSTRACT

The problems surrounding how we deal with stormwater run-off and issues such as drought, flooding and water pollution have been well publicised in recent years fuelled, to great extent, by the growing consciousness of climate change. The summer floods of 2007 throughout the UK also led to the publication of several reports such as Sir Michael Pitt's Interim Review and the more recent Flooding report from the House of Commons Environment Food and Rural Affairs Committee. DEFRA have also published Future Water, the Government's water strategy for England and all of these documents have heightened awareness of the benefits of sustainable drainage and the contribution that can be made to reduction of flood risk. There are many methods available and approaches in the SUDS 'toolbox' but all too often designers are restricted to 'soft' or natural options or what have become known as traditional SUDS, failing to consider some of the innovative proprietary solutions that have been used for many years which have provided very robust, cost effective and reliable answers. This paper will use an interesting case study to demonstrate how these systems have been used in conjunction with traditional SUDS options resulting in a complimentary, holistic solution helping create a whole sustainable community.

KEYWORDS

Sustainable drainage; SUDS; geocellular systems, rainwater harvesting, infiltration trench, infiltration blanket, infiltration basin, vortex flow controls, hydrodynamic separators, flooding, sediment control, siltation, aquifer recharge, attenuation, adoption, treatment train.

INTRODUCTION

In 2001, a joint venture between Bournville Village Trust and English Partnerships was signed to secure a planning consent to develop 72 hectares of land in the south-west of Telford, in the parish of Dawley Hamlets.

Promoting this development as an integrated and sustainable environment for the new millennium has been a consistent aim of the joint venture as well as maintaining the spirit of George Cadbury's pioneering achievements in Bournville in the nineteenth century.

The site is actually owned by English Partnerships who form one half of the joint venture, Bournville Village Trust forming the other half who are also a registered social landlord. Bournville Village Trust was established in 1900 and carried out the development of a model village alongside George Cadbury's chocolate factory in Bournville, Birmingham. That project initially comprised around 313 houses and 330 acres of land. Since then the Estate has grown to some 8000 houses with a broad range of tenure, approximately half rented under the

Trust's registered social landlord status. The Trust's desire to develop a 'New Bournville' at Lightmoor initiated the sustainable urban village community development discussed in this paper.

THE SITE

Lightmoor Urban Village is approximately 4 km from Telford town centre. To the north and east of the development site are the communities in Horsehay, Doseley, Little Dawley and the Lightmoor New Community. To the south, across the A4169, is the village of Coalbrookdale and Ironbridge Gorge and its historic Iron Bridge across the River Severn. To the south-east across the A4169, lie the residential estates of Woodside and Madeley. To the west, beyond Wellington Road and the A5223, is open countryside extending to the Wrekin.

The site is bounded by the Stoneyhill waste disposal site, Wellington Road, part of Horsehay Village and the boundary of a site occupied by Johnston Pipes to the north. To the east and south-east the site is bounded by land of ecological and landscape value designated as a wildlife site. Agricultural land forming a transition zone between the development site and the Wildlife Site bound the southern boundary and the A4169 Ironbridge by-pass bounds west.

Prior to commencement of development, the majority of the site was in agricultural use, primarily being used for grazing and of relatively low quality, mostly rated as grade 4 under the Department for Environment Food and Rural Affairs Agricultural Land Classification of England and Wales (DEFRA, 1988).

The site consists of a variety of slopes and valleys which has been altered in places by previous mining and waste-disposal activities. There is a general fall across the site towards the south-east from approximately 178m Above Ordnance Datum [AOD] in the north to approximately 125m AOD in the south.

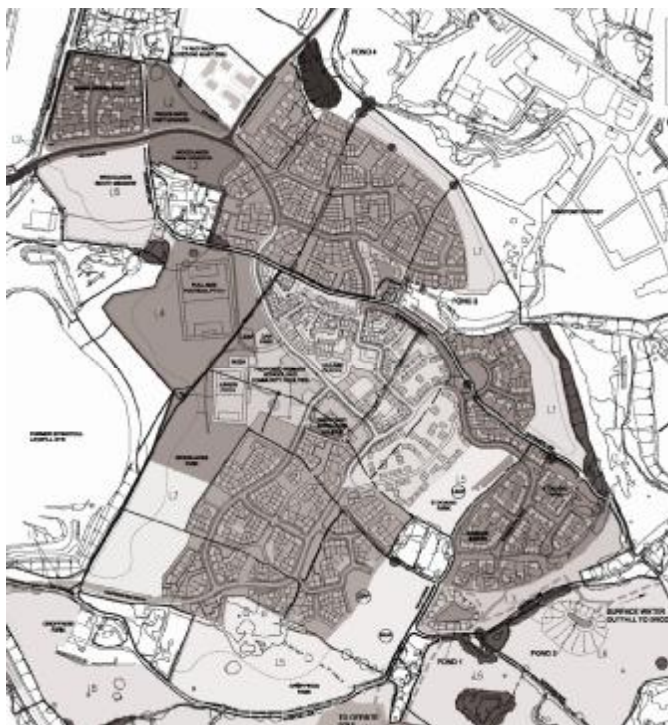


Figure 1. Extent of Site.

Campbell Reith Hill (CampbellReith), a leading firm of consulting engineers, were employed by the Trust in 1997 to provide advice for the development. Through numerous studies and investigations into the geology and hydrology of the area it was discovered that the area supported a very delicate hydrogeological balance including an underlying complex multilayered aquifer. The aquifer found its way to ground at a number of locations across the site in the form of natural springs. Some of these springs fed watercourses which in turn feed into the Lightmoor Stream running along the eastern boundary of the site in a southerly direction.

The Lightmoor Stream itself flows south into a series of reservoirs which have a regulated discharge into the Borough Banks Sewer ultimately discharging into the Ironbridge Gorge. The studies further indicated that existing rainfall from the site was likely to be infiltrating the ground and recharging the aquifer with a small percentage finding its way overland into the Lightmoor Stream and that development of that land could lead to changes in the delicate hydrogeological balance.

It was clear that any sustained increase in flow directly into the Lightmoor Stream would not only reduce recharge of the aquifer but would cause potential downstream flooding of the reservoir and sewer. Any proposed development of this area had to promote a clear synergy with the existing drainage patterns of the site.

There were no significant watercourses to be found on the site and no surface water drains were in existence. The land was well drained, with the exception of one small area. There were some short watercourses on the eastern side of the site that fed into a detention pond controlled by an orifice outlet which in turn fed into a concrete box culvert. Several springs also existed along the eastern boundary.

An analysis carried out by W S Atkins in 1998 highlighted the inadequacy of this downstream system to cope with any increased flows or to provide sufficient storage capacity, even if the heavily silted detention pond were cleaned out.

DEVELOPMENT PROPOSALS

Homes

Up to 800 dwellings, of which up to 50 units may be for living/work occupation, with a minimum of 25% affordable housing that will be provided and managed by Bournville Village Trust.

Education and Community

A one-form entry primary school and a community centre with indoor recreation facilities which includes life-long learning, healthcare, multi-faith worship, indoor sports, cultural and entertainment events, community management, ancillary facilities and associated car parking. The Borough Council applied for detailed planning permission in February 2007 for a single form entry primary school with a reception class – 210 pupil capacity overall. It is hoped to start construction later in 2007, subject to confirmation of funding, planning and other necessary approvals.

Village Centre

A mixed use Village Centre will contain a selection of small retail units and a family pub / restaurant all to be owned and managed by Bournville Village Trust. These, together with an area of formal open space and small offices for the Trust's own occupation, will form part of the first phase of the development of the Village Centre site. These facilities will be complimented by the incorporation of community and joint use facilities in the proposed primary school.

Open Space

Open space and landscaped areas are set around the development parcels, with no less than 22 hectares available for publicly accessible sports, play, recreation and leisure uses.

Open space guidelines include:

- A well-defined compact village surrounded by landscape
- A strong distinction between the recreational open spaces encircling the village and the protected rural wildlife site
- A mixed-use centre arranged around the High Street and a village green, located so that foot access is promoted
- Higher residential densities clustered around the Village Centre, with areas of lowest density at the edges of the village where transformations between urban and rural character are made
- The character of the existing lanes is retained and they are integrated into the movement network as recreational routes for pedestrians and cyclists

DRAINAGE CONSIDERATIONS

To deal with all the future surface water drainage requirements as well as the previously mentioned hydrogeological issues, Sustainable Drainage (SUDS) was investigated as a solution and was, at the time, one of the earliest projects to consider this innovative technique.

It was clear that any attempt to utilise a traditional drainage network would require significant attenuation volumes to meet Greenfield runoff criteria as well as requiring significant drainage works downstream of the site.

Sustainable Drainage looks to minimise the negative impact of development on both the existing local hydrology and also the downstream watercourses and sewers. In the case of Lightmoor the aim was to present a scheme that returned as much water back into the ground, to recharge the aquifer, and minimise the impact of discharge to the Lightmoor Stream and consequential flooding.

As the joint venture were only installing the primary infrastructure and promoting the development of individual plots of housing it was imperative that SUDS was introduced into the primary infrastructure. CampbellReith designed a drainage system that will receive a nominal discharge from each of the housing phases (based on 15 l/s/ha) and feed flow through a series of infiltration blankets, infiltration trenches, infiltration basins and ponds before allowing a final discharge into the Lightmoor Stream of some 23 l/s. The trenches, blankets and basins serve to return as much of this water to ground to enable aquifer recharge whilst the ponds attenuate the final flow from the site into the Lightmoor Stream.

The net result is a development of some 800 houses, village centre and school which has a discharge equivalent to only 0.3 l/s/ha.

At this point it should be noted that a traditional surface water design would have produced a network of sewers collecting all the surface water from the development, conveying this to the natural low point of the site and discharging it all into the stream of the highest flow rate possible. Attenuation of the drainage would have been through the use of oversized pipes and underground tanks.

The primary SUDS infrastructure is supported by a requirement from the joint venture to the tendering developers to seek sustainable drainage solutions to their developments in order to reduce their surface water flows to the limited 15 l/s/ha. Tenderers are encouraged by the joint venture to make use of soakaways at or near properties, install Rainwater Harvesting Systems and large 'communal' infiltration systems in preference over traditional piped systems.

ADOPTION

CampbellReith have sought to engage the local water authority, Severn Trent Water in securing an adoption of the entire surface water system under Section 104 of the Water Industry Act 1991. However, after two years of detailed negotiation with Severn Trent Water an impasse which could not be overcome was arrived at. Under current legislation (Water Industry Act 1991) and funding provision through OFWAT there exists no formal mechanism which provides the water authority with funding in order to maintain sustainable drainage devices. In such a commercial world it was difficult for Severn Trent Water to proceed with full adoption without a funding mechanism.

The final drainage design provided by CampbellReith was fully compliant with the requirements of Sewers for Adoption 5th Edition. This required that the drainage will perform in a 1:2 yr storm without surcharging and in a 1:30 yr storm without flooding. It was also a requirement to comply with the Environment Agency condition for flood routing in the 1:100 yr event, such that no properties, new or existing, are put at risk in the 1:100 yr storm event.

After some additional negotiation an agreed position was arrived at whereby Severn Trent Water offered to adopt the entire pipework structure under Section 104, subject to agreements. Bournville Village Trust retains ownership and maintenance responsibilities of the remaining SUDS features to an agreed standard.

Until legislation and funding mechanisms are amended to allow adoption Bournville Village Trust will work with Severn Trent Water to maintain the overall Sustainable Drainage System which serves this unique development and protects the environment in which it is located.

SUSTAINABLE DRAINAGE DESIGN

Accurate infiltration information was obtained through on site testing and following detailed design work and modeling a 'treatment-train' approach was developed which incorporated a range of SUDS features that provided the necessary hydraulic requirements as well as integrating with the built environment with an aesthetically acceptable design.

The final solution comprises a mixture of attenuation ponds (figure 2), infiltration blankets with granular fill and perforated pipework (figure 3), infiltration blankets with geocellular modules incorporating inspection / access tunnels (figure 4), infiltration trenches with both granular material as well as geocellular modules (figure 5), and hydrodynamic separators to remove sediment and silt and protect the above attenuation / infiltration features (figure 6).

The important flow control regime was provided with the use of vortex flow controls each individually designed to provide the precise flow requirements corresponding with the hydraulic analysis and modeling carried out at design stage. These flow controls were subsequently supplied to site, pre-installed in their own precast concrete chambers (figure 7). Due to the phased nature of the development, scheduled to take place over several years with completion expected around 2014, a SUDS construction management strategy was developed by CRH. This strategy ensured that the various features were not only constructed in the correct sequence, but that they were commissioned at the correct time and that the maintenance procedures were put in place to ensure longevity of the system, particularly during the early years when damage due to siltation could easily occur if not managed correctly.

All of the infrastructure SUDS features were installed during phase 1 of the construction program. There are seven phases planned in total with a pre-defined program in place dictating when each of the features will be brought on-line and when and how they should be maintained.



Figure 2. One of several Lightmoor attenuation ponds within 2 years of construction

These features consist of 3 attenuation / infiltration ponds, 2 infiltration blankets and 4 infiltration blankets. Each of these features is precluded by a hydrodynamic separator and the outflow is controlled with a vortex flow control. The construction management strategy laid down the requirement to inspect the separator devices on a regular basis in the initial stages of construction to establish the required frequency for cleaning / emptying, dependent upon the level of sediment captured.

The design also included the facility to by-pass each of the major SUDS features to allow isolation should failure occur and the initial design and modeling included ‘testing’ the system with one or two of the SUDS features being unavailable.

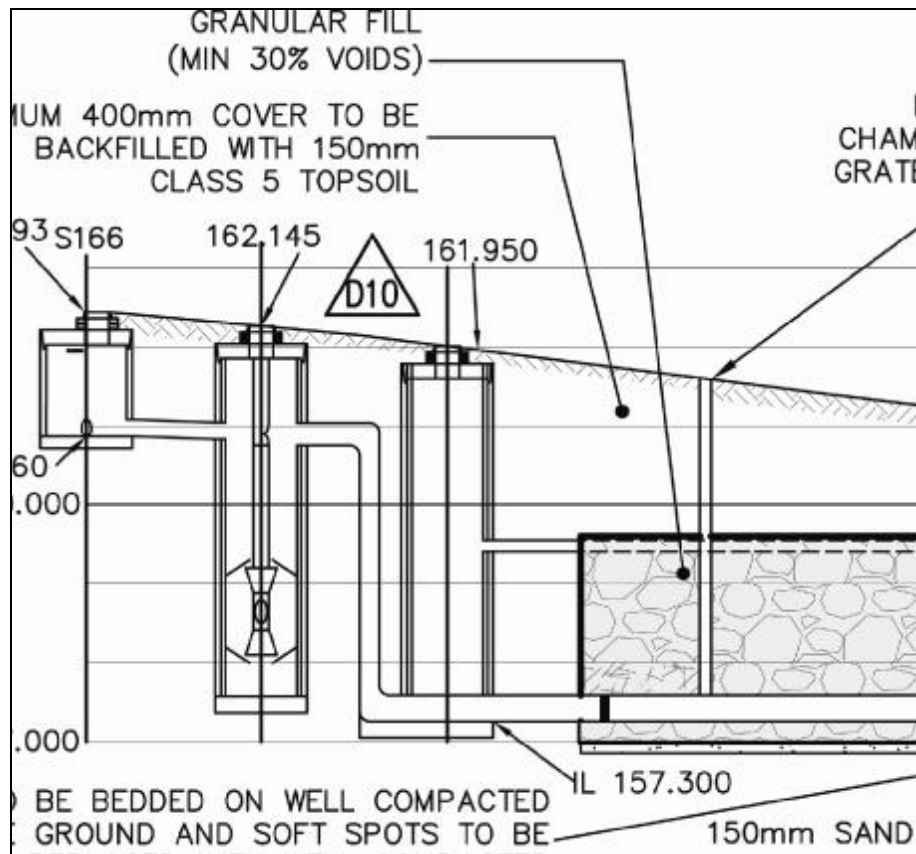


Figure 3. Extract from granular fill blanket construction detail showing hydrodynamic separator prior to connection

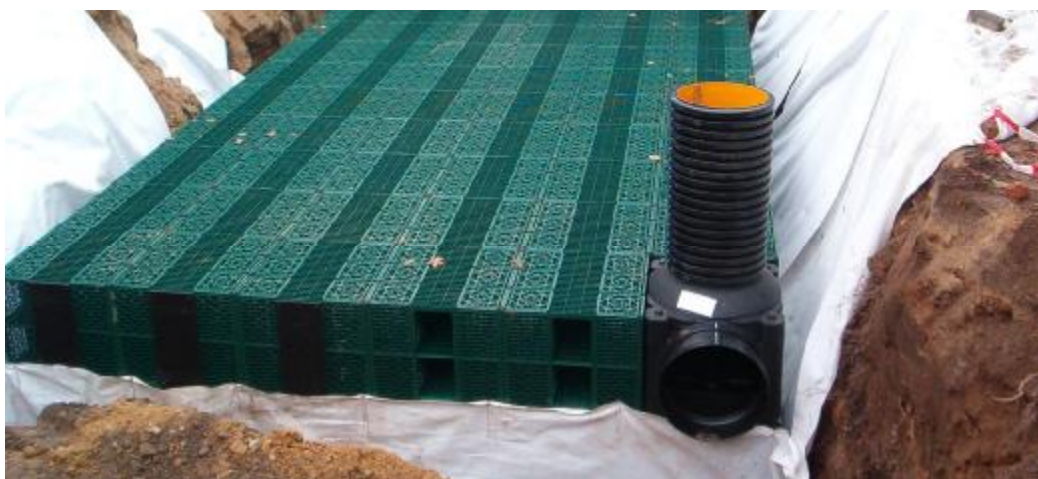


Figure 4. Stormbloc® Geocellular modules used to construct an infiltration blanket showing integral access and inspection tunnels

The SUDS features described above provide the attenuation for all the surface water runoff from the infrastructure as well as the runoff from each of the housing phases which will be restricted to 15 l/s/ha. The developers who are currently building houses on the initial phases and those that continue to develop the remainder of the site, will be required to adhere to the SUDS principles mentioned previously.

Whilst there will be flexibility for the developer to propose different systems and approaches in the future phases, there were specific reasons why the solutions specified were used in the provision of the infrastructure SUDS features.

The geocellular modular system (Stormbloc®) was chosen due to the high strength capabilities coupled with the ability to be able to inspect the storage volume via the integral / patented tunnels which form part of each of the blocks. The blocks are aligned in the infiltration trench or infiltration blanket to form a continuous tunnel, or series of tunnels, through the entire structure allowing future inspection, if necessary, from strategically positioned access chambers.

The hydrodynamic separators (Downstream Defender®) were included prior to the storage / infiltration devices to capture the majority of the sediment and silt, particularly during the construction periods. These devices can be easily inspected and maintained and the sediment removed without the often expensive and complicated maintenance procedures necessary with some ponds / basins and buried, granular material based, infiltration devices.



Figure 5. Stormbloc® geocellular modules during the construction of one of the infiltration trenches at Lightmoor



Figure 6. Downstream Defender® hydrodynamic separator – silt and sediment removal device used prior to infiltration devices and ponds



Figure 7. Hydro-Brake® vortex flow controls used to attenuate flows from ponds and infiltration devices

SUMMARY

The major barrier to further uptake of SUDS and an increase in development examples such as the one described in this paper, is legislative inadequacy. Even when the sewerage undertaker is keen to work with the designers and developers in the provision of a viable SUDS solution which they would have been happy to adopt on a technical basis, they are thwarted by the funding provisions and the legal definitions of a sewer.

The recent flooding reports published as a result of the summer floods of 2007 have indentified this barrier, along with many other regulatory changes that must be made along with clarification of the issues relating to ownership and maintenance responsibilities.

Proprietary SUDS systems can provide a very cost effective and viable solution when designing sustainable drainage systems and can complement what have become known as traditional or 'soft' SUDS solutions such as ponds and swales for instance.

There are some very good examples of where proprietary systems have been used to not only provide robust and efficient solutions, but have been the key to moving a particular project forward and providing the only answer in some cases.

The SUDS Manual - C697 (CIRIA. 2007) has extensive coverage of these types of systems and gives useful design guidance on the use of all the systems mentioned in this paper.

British Water have also produced a guidance document on the selection of proprietary sustainable drainage systems and components which gives easy to use look-up charts covering the four principle areas of proprietary SUDS solutions namely Infiltration, Storage and Attenuation, Flow Control, and Treatment.

Space constraints are generally one of the barriers to the inclusion of SUDS, thrown up when considering stormwater drainage designs, but due to the very high void ratio and compressive strength of some geocellular systems, they can be incorporated into a treatment train type system without taking up valuable space, allowing developers and designers to provide some very interesting and innovative solutions.

Sediment removal devices, particularly hydrodynamic separators, are particularly effective at removing grit, silt and sediment and can help reduce not only the overall size of open ponds and basins, but help reduce the maintenance requirements of these features too.

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