Defra's Water Availability and Quality Evidence Programme

Comparative Costings for Surface Water Sewers and SuDS.

Daniels Cross, Newport, Shropshire.

Technical Report

Produced: February 2011

Author: Graham Fairhurst

defra
Department for Environment
Food and Rural Affairs

Research contractor: Department for Environment Food and Rural Affairs

Defra project officer: Rachel Boulderstone

Publishing organisation
Department for Environment, Food and Rural Affairs
Water Availability and Quality,
Ergon House,
Horseferry Road
London SW1P 2AL

Tel: 020 7238 3000 Fax: 020 7238 6187

www.defra.gov.uk

Published by the Department for Environment, Food and Rural Affairs (July 2011).

Contents

1. Location

1.1 The development is located on the eastern edge of Newport, Shropshire, within Telford & Wrekin Borough (a unitary authority) and almost abutting the county boundary with Staffordshire. Newport is surrounded by agricultural land and is a small free-standing, former market town with about 12,000 inhabitants. It is a popular place to live on account of its schools and ease of commuting by car to Telford, Stafford, Wolverhampton and the rest of the West Midlands. There are therefore significant development pressures on the town.

1.2 When the site was under development, the area had a two tier local government system with Shropshire County Council being the highway authority and Wrekin District Council being the planning authority and also at the time acting on behalf of Severn Trent Water (under sewerage agency arrangements) for the sewerage systems.

1.3 The National Grid Reference of the site is: SJ 755155.

2. Site Characteristics

2.1 This is a 7.07ha site which is situated in an area with relatively flat topography. The site slopes gently from south to north and on its eastern and north eastern edges has shorter, steeper slopes down to lower lying land in the valley of the small River Strine. The lower land of the Strine valley is largely undeveloped and mostly comprises active flood plain which is for the most part used for informal open space and grazing. To the west the site abuts established residential development from the 1930s and 1950s and to the north, informal parkland part of which is on an old landfill site.

2.2 The sub-soil conditions in the wider area are mixed glacial deposits: clays, sands and gravels. This particular site is underlain by sands and has good permeability.

2.3 The site was developed in 1998. Prior to development the site was largely agricultural/greenfield. Following the construction of the Newport by-pass (A41) in the 1980s, the site became isolated from the extensive agricultural land on the east of the by-pass and permission was sought for its development. The form and extent of the developable area was readily established as the eastern edge was formed by a bluff dropping three to four metres down to the by-pass and the northern edge bounded by the landfill and flood plain of the Strine.

2.4 The development, for the most part, comprises 156 medium sized detached housing at a relatively high density. There are also 15

smaller terraced, ‘starter homes’ within the site giving a total of 171 houses at a density of 24.2units/ha. Within the development there is a minimum of public open space for amenity and play space. There are no highway verges. Visibility splays at highway junctions are incorporated into garden areas. To the north, an adjacent park area and the flood plain land provide informal open space. There has been a clear policy by the County Council as highway authority and the District Council to reduce adoptable public open space and their maintenance liabilities.

3. The Highway Layout

3.1 The site has a single highway access from the existing highway network, from the south. The highway layout within the development is very traditional, with the main access road running through the site as a spine road with several cul-de-sacs off it. The highway space represents a significant part of the development. All of the roads have kerbs and footways on each side and the carriageways and footways are surfaced with bitumen macadam. Highway drainage is to conventional gullies. There are no traffic calming features.

4. The Surface Water Drainage System as Built

4.1 Surface water drainage is all to a traditional pipe system which largely follows the highway network and flows northwards to outfall into the River Strine. All of the properties are drained by private drains and private sewers to a sewerage system which was adopted through a Section 104 agreement under the Water Industry Act. The highway gullies are connected to the adopted surface water sewers via pipe connections. There are no separate highway drains.

4.2 As the site is fairly recent, there was a requirement from the Environment Agency to limit the discharge rate to the River Strine. Unfortunately the exact requirements in this connection are not readily available, but the development incorporates a substantial balancing basin at the downstream end of the surface water sewer. This basin is formed of quite large earth embankments with engineered inlet and outlet structures and has a substantial storage volume although the exact figure is not readily available. As Severn Trent Water has a policy of not adopting above ground balancing features, this basin was adopted by Wrekin Council with a commuted sum obtained for this purpose. The basin and embankments are grassed and are mown three or four times per year. The feature has low amenity and biodiversity value.

4.3 All of the highways and house driveways are surfaced with tarmac. There is no porous paving within the site, nor are there any other SuDS features although some householders may have installed rainwater butts.

5. The SuDS Concept

5.1 It is important to recognise that the SuDS concept is essentially one of retro-fitting a SuDS solution within the pre-determined layout. This is a sub-optimal approach for implementing SuDS and will incur additional costs for the concept and hinder the delivery of most of the added value issues. The best practice approach for the implementation of SuDS is one where the SuDS concept and details are used a theme to shape the overall development concept. This secures efficiencies within infrastructure and land use and should result in more attractive features and interesting development.

5.2 The retro-fitting approach has been used because it avoids any significant redesigning of the estate and opening up potential conflicts with the original developer intentions and with other policies and regulations e.g. planning policies.

5.3 Whilst subsoil conditions within this site would probably permit a SuDS solution that relied completely upon infiltration, no test information is available to demonstrate that soakaways and porous surfacing alone could be relied on to work effectively.

5.4 If it had been shown that soakaways and porous surfacing would work effectively, the SuDS concept would have been as follows:-

5.5 All surface water drainage for the 1 in 30 year event to be dealt with by source control techniques.

- For the highways this would be porous surfacing and/or gullies leading to soakaways and/or surface drainage to infiltration basins.
- For the properties this would be porous surfacing to driveways and/or soakaways and roof water going to soakaways.

5.6 The 1 in 100 year event would be managed by securing continuous flow paths along the routes of the highways toward the River Strine and by use of the public open space area in the flood plain.

5.7 There would be no adoptable SuDS with this concept as all highway drainage would form part of the highway infrastructure and all property drainage would be independent of neighbouring property and of the highway.

5.8 This would have been a significantly lower cost solution than the storage and conveyance SuDS concept that follows and which has been used as the basis of the estimate.

5.9 The SuDS concept actually employed is a secure and robust one, based upon a storage and slow conveyance system which takes advantage of the opportunities for infiltration but does not depend upon

flow loss through infiltration. For security, the storage and conveyance components are sized without assuming any water loss through infiltration.

5.10 Surface water from the highway is drained into porous surfaces and/or on the surface via short routes to swales or basins. The concept assumes the highway is shaped to fall toward the swales and/or basins.

5.11 Experience indicates that with high car ownership, parking of vehicles on verges and swales can be problematic. Therefore it has been assumed that a kerb with drainage openings in the face is provided between the carriageway and the swales. Alternative solutions to this issue could be 'hit and miss' kerbs, bollards, low 'trip rail type of fencing and/or shrub planting at the edge of the swale/basin and these may be suitable in some parts of the site.

5.12 The principles employed for the SuDS are:

a) Source Control:

- Porous paving of the adopted cul-de-sacs (it is assumed that the spine road through the site is surfaced with conventional tarmac).
- Porous paving of the house driveways.
- Roof water 'disconnection' with downspouts discharging to rainwater butts which overflow to individual garden swales or filter drains and/or into the porous stone structure beneath the porous paved driveways and with residual discharge passing to the adoptable swales.

b) Local Control:

Adoptable swales and detention basins which form a continuous, slow conveyance system, which in general follows the same routes as the surface water sewers did. The system works at two levels:

1. A surface based swale system (with the main swales 1.8m wide and of 'V' section, with a depth of 0.3m). Wherever space allows, detention basins have been included within the swale system.
2. A slightly deeper, porous pipe system which sits beneath the centre line of all of the swales, except for the final, upstream lengths on each branch. This deeper system is intended to take flows beyond the capacity of the surface swales and there are 13, grated inlets from the surface swales to the lower system.

Space for the swale was created by eliminating one footway through the whole development and compensating for this by widening the other footway by 0.6m. It has also been assumed that between 0.5m and 1.0m strip of front gardens would come into the public

realm (highway area) to give enough space for the SuDS features and the widened footway. In omitting one of the footways, care has been taken to ensure that all properties have easy access to the single footway. Normally the footway that has been omitted is on the side of the road with fewest properties/accesses. The configuration of the street in cross-section is therefore:

Footway – Carriageway – Swale.

The basins have been assumed to be shallow, generally not more than about 400mm deep so that they will have opportunity to infiltrate water but will not retain more than about 100mm depth in drier periods of weather. It is assumed that they will be landscaped and may have some shrubs and trees around and within them. It has been assumed that six of the basins will have flow control devices in their outlets so as to secure the proper mobilisation of storage within the system.

The basins have been made as large as reasonably possible in area and have been located wherever the site layout had some open space. They have all been placed in visible areas which have direct connectivity to either the highway or to other public open space (for oversight and maintenance). The locations comprise:

- Public open space - Here, they have generally been placed in what would otherwise be less usable corner positions so as to retain the availability of larger, flat grassed areas for recreational games.
- Some garden areas - Here, flank frontages of properties have provided opportunities, as have visibility splays at junctions and peripheral corner areas of front gardens in awkward shaped plots. In these cases, it is assumed that the land occupied by them would become public open space or would be covered by an easement to allow the SAB to maintain them.
- Highway (carriageway) areas - Here, it is assumed that the road narrowing for the basins would be combined with a function of traffic safety/traffic calming and also provide some opportunity for landscaping to make the existing rather bland street scene more attractive. These have often been located along the flank frontages of properties and in all cases, care has been taken to ensure that they do not impede vehicles turning into driveways.

5.13 In order to provide full continuity within the surface system of swales and basins some sections of pipe (200mm diameter) are necessary beneath highways, particularly at junctions. Because these sections of pipes are extremely shallow, protecting ‘cover’ (and space for a concrete surround) has been secured by assuming a ‘raised table’ form of traffic calming is put in place over the pipe. These

features increase the total cover to about 250mm. Where driveways cross over swales, it has been assumed that the driveways are profiled:

a) to ‘summit’ slightly over the pipe itself to provide extra cover. And:

b) to provide a ‘low spot’ at the drop kerb adjacent to the highway; this to provide a surface (contingency) flow path should the pipe block.

5.14 Locating the swale on the side of the highway with fewest properties reduces the number of piped sections within the swale.

5.15 In all cases where a basin or swale discharges into a pipe or a pipe discharges into a basin or swale, no engineered headwalls or gratings would be built (the concept assumes that all pipe entries are formed by shaping the swale around them). Care has been taken to ensure that all connections between piped sections occur in the open at basins and swales. There are no manholes within the concept.

5.16 The ‘under-draining’ pipes beneath the swales form a fully connected system which is independent from the surface system of swales and shallow pipes (being connected only by the specific inlets). The ‘under-draining’ pipes sit within a trench of standard pipe trench width for the pipe sizes (mostly 250mm diameter and 300mm diameter at the downstream end) and have pipe soffit 150mm below the swale invert giving a maximum depth of these pipes to invert of the order of 750mm. This is a comfortably safe depth for excavation work without the need for expensive trench support systems and the scale of these works will yield relatively small amounts of surplus material for disposal. Access to this system for any maintenance work is via the inlets from the swales.

5.17 The adoptable, local control SuDS system flows to the Strine valley. At the location where the current embanked basin has been provided, it is assumed that a soft engineered flood meadow area is provided instead. This would have a controlled outlet (low weir) to the River. The surface swale system and the piped ‘under-drainage’ flow separately into this flood meadow enabling them to be separately monitored.

5.18 Where the concept envisages areas of private space within housing plots being brought into the public realm to accommodate SuDS features, this would not affect the aspect of the plots as there would still be the same amount of overall open space. The estate is ‘open plan’ and the effect would be one of taking small amounts of private open space (which in many respects provides public amenity) into the public realm. Such adjustments would not have significant effects upon the attractiveness of plots and are seen as having no cost as they would be made at the time of designing the development. If

these areas were brought into the public realm, it would often be possible for the SAB to grant householders permission to plant within the swale or to maintain the grass to the standard that the householder would wish (i.e. to manage it to all intents and purposes as part of the garden). An alternative to bringing these small pieces of garden areas into the public realm would be for them to be left as private garden land and for the adopted SuDS to be secured by means of easements established at the time the estate is designed and laid out by the developer. The latter is an established method used to secure service strips for utilities within garden areas in developments without footways.

5.19 The concept provides for the local control system to deal with the 1 in 30 year event.

5.20 The 1 in 100 year event is managed by securing a viable, continuous flood route through the development along the route of the swales. The 100 year event would be handled within the highway and adjacent strip of front gardens.

6. The Estimates

6.1 These are shown in Appendix 3. The approach taken with the estimates has been to identify only those elements of the development that change between the sewered and SuDS concepts and then to estimate the difference in the total costs of these changes. The changes are principally in connection with the drainage infrastructure itself (e.g. swales instead of sewers) and surfaces (e.g. porous paving in some areas instead of tarmac). The estimates therefore represent only a proportion of the total infrastructure costs of the development.

6.2 The rates used are local ones from Telford & Wrekin Council's annually tendered minor works contract. These were felt to be locally more appropriate than using Spons. The rates have been used consistently for all of the estimating for both the SuDS and the sewered options in order to have a sound basis for comparison.

6.3 There is little doubt that a bespoke, tendered contract for each of the concepts would have secured lower rates and lower out-turn costs for both the sewer and SuDS schemes.

6.4 The total estimated cost for the sewer features is £889,052.
The total estimated cost for the SuDS features is £780,836.
This represents a saving per plot of the order of £615 with the SuDS concept.

7. Opportunities for SuDS if the site layout had been modified

7.1 In many developments of this type there are often grass verges and if these had been provided then it would have been a simpler matter to convert them into swales, without having to create space within the existing layout.

7.2 The public open space within the site itself was located in one place remote from the main swale route. For a SuDS scheme based upon storage and slow conveyance this is sub-optimal as it would have been preferable to have the space at more than one location, toward the lower end of the site, probably more visible and closer to the main swale route. If SuDS had been used to help shape the development, there could have been opportunities to locate some properties fronting onto green spaces with ponds which formed part of the SuDS system.

8. Benefits

8.1 A significant benefit in this case would be the opportunity for SuDS to enhance the attractiveness of the estate. The SuDS would enable some of the extensive and bland tarmac areas to be softened by introducing more trees and shrubs and generally better landscaping. The highway layout has no traffic calming content and SuDS could contribute to making the estate safer for children and perhaps produce a development with a different character with more life in the public realm. Biodiversity within a development of this type is not a particularly strong theme and use of SuDS would greatly enhance this aspect; in particular through the basins and ponds.

8.2 The slow conveyance and attenuation of flows will have the effect of removing pollutants and reducing the diffuse pollution load carried by the surface water sewer system into the River.

8.3 As most of the SuDS features are visible within the estate, they will be subject to oversight by the residents. In this way the features can provide an educational resource and evidence to the residents that their development is placing reduced demands upon the wider environment. Simple, surface SuDS features such as the ones which could be used here, can lend themselves to local, co-operative maintenance by residents, particularly as risks and skill requirements are both very low. Where co-operative inputs are mobilised, they can have beneficial effects in helping to build a stronger and safer community.

9. Lessons Learnt

9.1 The concept has been developed by considering numerous themes in a holistic manner. These include:

- Aesthetics within the development.

- Residents needs.
- Access within the development for service vehicles.
- Access to all properties by vehicle and foot.
- Traffic safety.
- SuDS safety.
- What can be expected of residents and visitors in terms of parking culture.
- Using ‘green spaces’ for both landscape and surface water management.
- A viable flood route.

9.2 In particular the work has highlighted the need for the SuDS to be designed in terms of both concept and detailing in conjunction with the highway concept and its detailing. This SuDS has involved some alterations to the highway concept, mainly the removal of one footway and compensating widening of the other footway. It has also involved introducing some traffic calming measures. None of these modifications ought to present an obstacle to the highway adoption and they actually make for a safer and more attractive development. It is interesting in that incorporating the SuDS in this way modifies the thinking around the highway in a way that many planners and highway engineers already are doing.

9.3 If it were considered essential to have footways on each side of the main route through the site, then space for the swale would have had to be created by reducing the lengths of the front gardens by 0.9m on each side of the road. The configuration of the street in cross-section would then be:

Footway – Swale – Carriageway – Swale – Footway.

A swale on one side of the carriageway only would have ‘under-drainage’. This configuration would give a more traditional, but less interesting street scene.

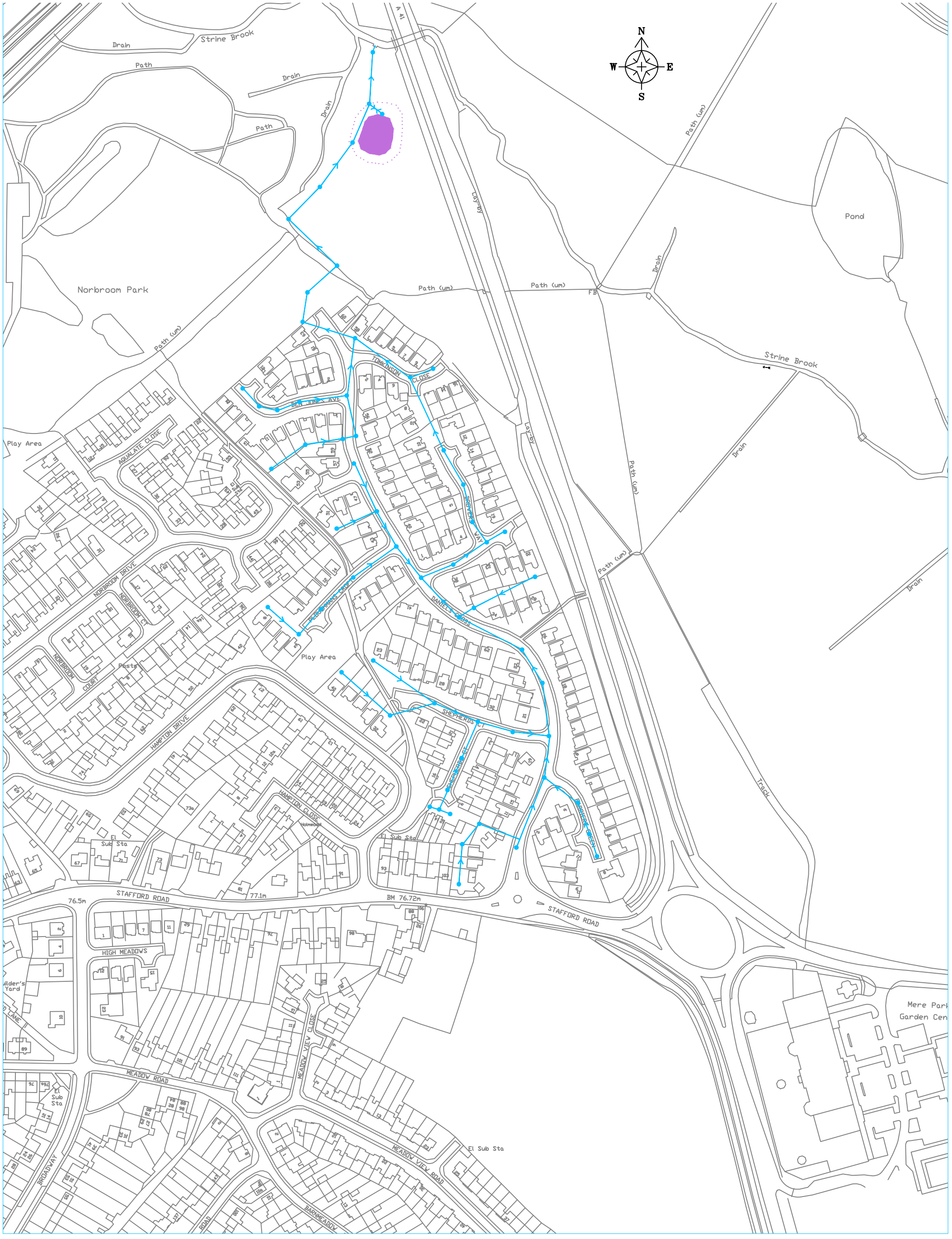
9.4 In the case of this estate, there was very little open space passed over to the local authority for management as landscape. As indicated, areas such as visibility splays have been instead conveyed to householders as garden areas. In other estates, areas such as visibility splays and verges would have been passed over to the local authority for maintenance. Practice in this respect varies between local authorities and highway authorities, although there has probably been a tendency in recent years for reduced amounts of these types of open space to be accepted by the councils for maintenance. The significance of this variation in practice is that where the landscape is adopted by the council, the cost of maintaining the area as SuDS becomes a relatively small ‘add on’ cost. Whereas in cases where the open space has not been adopted as highway visibility splays or for general amenity, the maintenance costs for the SAB or local authority would need to include the costs of maintaining the areas to amenity

standard as well as for the SuDS function. It is possible that at least some of the adopted SuDS features could be located in private land so that the amenity level of maintenance would be covered by the householder. Access by the SAB for any inspection and other maintenance work could be secured through an easement.

10. Summary

10.1 The exercise has shown that a development of moderate density which has only a small amount of public open space is amenable to a storage and slow conveyance SuDS drainage solution which is compliant with the proposed Standards. The exercise has shown the extent to which highways can dominate residential development layouts and how important it is not just for the highways to be drained to SuDS but for the highways and SuDs concepts to be woven together as an overall concept. The exercise also indicates that SuDS in this type of development can offer significant benefits beyond those of flood risk and water quality and can provide a cheaper drainage solution than traditional sewers.

10.2 As indicated in paragraphs 5.3 – 5.8, this site could probably have been drained to infiltration type SuDS which would have offered a cheaper solution. If ground conditions on this site had not been completely suitable for a scheme totally dependant upon infiltration, then such techniques could still have been used in conjunction with the storage and conveyance SuDS features and would have probably reduced the sizes, extent and cost of these features. It is felt that the approach taken: using a SuDS concept that does not rely on infiltration, is useful as it represents in effect a ‘worst case’ scenario in terms of costs attributable to a SuDS scheme in a development of this type.



Key:

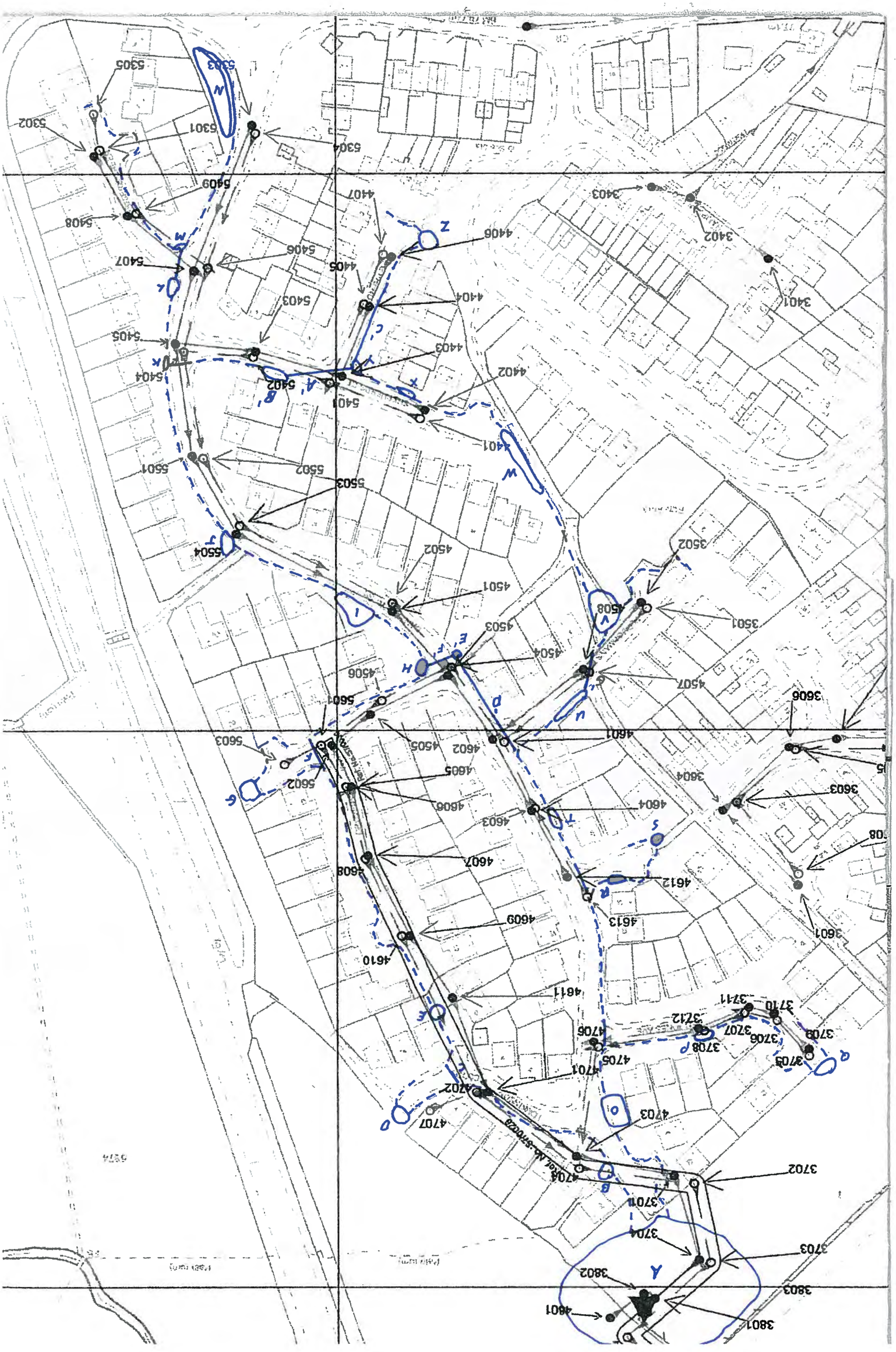
- Surface Water Sewers
- SW Underground Storage Pipes
- Watercourse
- Culverted Watercourse
- Swales
- Pipes
- Basin or Flood Meadow
- Floodable Area
- Pond

Case Study 1

Daniels Cross

Surface Water Sewer Plan

Scale : 1:2500


5303
5305
5302
5301
5304
5409
5408
5407
5406
5403
5405
5404
5402
5401
5501
5502
5503
5504
4502
4501
4503
4504
4506
5601
5603
5602
4605
4606
4603
4607
4608
4609
4610
4611
4707
4406
4405
4404
4403
4402
4401
3403
3402
3401
3502
3501
4508
4507
3606
3604
3603
3608
3601
4612
4613
3711
3710
3712
3707
3706
3708
3709
3703
4706
4705
4701
4702
4707
4703
4704
3702
3701
3704
3703
3802
3803
3801
4801

APPENDIX 3

Case Study 1 (Daniels Cross), Estimate.				
Item	**Standard Drainage**		**SUDS**	
	Qty	**£**	**Qty**	**£**
Pipework	1237m	157,130	1198m	81,460
Manholes	52 nr	67,660		
Gullies incl. connections	72 nr	16,650		
Catch Pits			13 nr	4,511
Gulley Pipework	144m	6,336		
Balancing Pool – Excavation	962m^3	5,002		
Basins – Excavation			600m^3	3,120
Balancing Pool – Re-used Fill / Deposition of Fill	2,452m^3	37,271		
Balancing Pool - Soft Spots and Fill	140m^3	5,400		
Balancing Pool – Compaction	2,452m^3	5,149		
Balancing Pool – Completion of Formation	2,452m^3	1,471		
Balancing Pool – Clay Liner	192m^3	4,608		
Balancing Pool – Disposal	962m^3	24,050	1,263m^3	31,575
Balancing Pool – Headwalls / Control Devices	3 no.	13,000	6 no.	6,000
Excavation and Trimming of Swales and Basins			3,052m^2	1,831
'Ditch' to Strine Brook Including Liner (150mm thick)			202m^3	1,050
Swales - Excavation			250m^3	1,300
Topsoil / Seeding	2,271m^2	2,725	3,052m^2	3,662
House Connection – Pipework (say 20m / house)	5533m	243,467		
House Connection – Pipework or channel (20m/house)			5533m	267,797
Driveway - Surface Course (40mm)	2,490m^2	21,165		
Driveway - Binder Course (60mm)	2,490m^2	24,900		
Driveway – Sub-base (Type 1)	374m^3	11,952	374m^3	11,952
Driveway – Additional Sub-base (Type 1)			374m^3	11,952
Porous Block Paving to Driveways			2,490m^2	70,128
Driveway – Geotextile Membrane			2,490m^2	3,486
'Cul de Sacs' - Surface Course (40mm)	2,390m^2	21,165		
'Cul de Sacs' - Binder Course (60mm)	2,390m^2	24,900		
'				
'Cul de Sacs' – Sub - base Course (Type 1)	718m^3	22,976	718m^3	22,976
'Cul de Sacs' - Porous Block Paving (80mm thick)			2,320m^2	74,240
'Cul de Sacs' – Geotextile Membrane			2,320m^2	3,3463,248
'Cul de Sacs' – Additional Sub – base (Type 1)			349m^3	11,168
'Raised Platform' over 'swale pipe' road crossings			330m^2	8250
Tree Planting			50 nr	10,000
375mm dia. Inlet Pipe to pool (£750)	10m	Incl. in P'work		
225mm dia. Outlet Pipe (£590)	10m	Incl. in P'work		
375mm dia. 'Bye Pass' Pipe (£2,250)	30m	Incl. in P'work		
Manholes to Strine Balancing Pool (£5,500)	2 no.	Incl. in M'Holes		
Sub Total		**716,977**		**629,706**
Prelims 14%		100,377		88,159
Design Supervision 10%		71,698		62,971
Total		**889,052**		**780,836**
House Number	171			
Site Area	70,654m^2			
Density	24.2 Units/ha.			

APPENDIX 4

Case Study 1, Photographs.

Photograph by G.Fairhurst

Typical cul-de-sac. Showing scope to introduce porous paving and swale or basin.

Photograph by G.Fairhurst

Informal amenity land. Site for flood meadow.

Case Study 1, Photographs (continued).

Photograph by G.Fairhurst

Main spine road through the estate. Showing scope to introduce a swale.

Photograph by G.Fairhurst

Visibility splay at road junction. Showing scope for basin.