

**DRAFT**

**JULY 2015**

**CATCHMENT STUDY  
AND  
PRELIMINARY FLOOD ALLEVIATION OPTIONS**

**STOKEINTEIGNHEAD  
DEVON**

**FOR  
DEVON COUNTY COUNCIL**

**REPORT REF. NO.: 421/SITH/FAS1  
V3 – 14.07.2015**

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## 1.0 INTRODUCTION

### 1.1 Study Background

TeignConsult was commissioned by Devon County Council (DCC) to undertake a catchment wide flow study and investigate preliminary flood alleviation options for Stokeinteignhead drawing on the earlier report of March 2014.

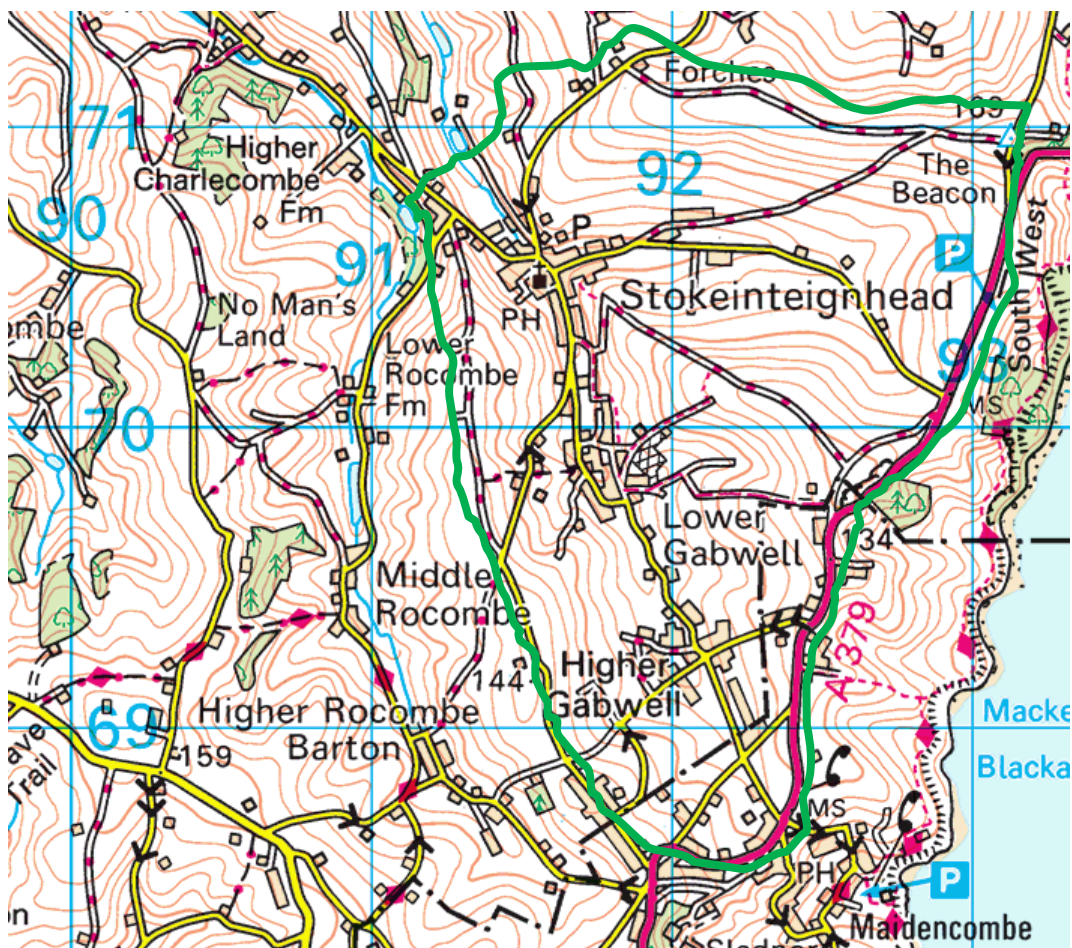
This study has looked at the sources of runoff that create the flooding including field runoff, watercourses, public and private paved areas, roof areas, and recent development planning consents with drainage related planning conditions.

The Parish Flood Group has provided copies of their survey work locating gullies and buddle holes and they have also assisted in catchment walkovers with anecdotal information on flooding.

A walk through of the two watercourses (southern and eastern) has been undertaken independently. During this exercise check measurements of the pipes, culverts and any other structures which impact on flood flow routes has been undertaken. During these walkovers the topography has been considered for potential flood storage areas.

### 1.2 Site Location

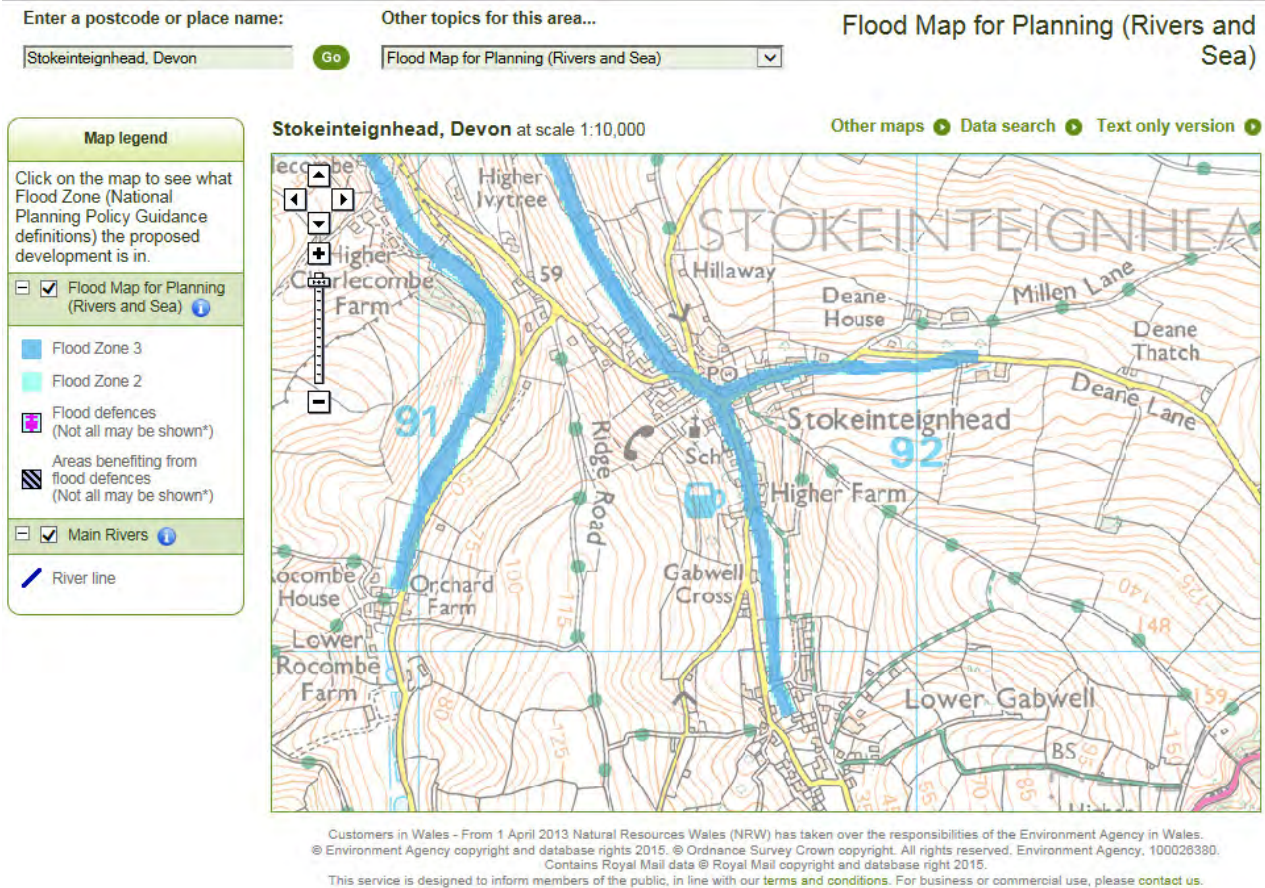
The study extends from Ashbury (Ivy Tree Hill) and The Palmes (Forches Hill) in the north, Labrador Bay Car Park in the east, Ridge Road in the west and the A379 Teignmouth Road near Maidencombe in the south. The eastern and southern boundaries of the watercourse catchment extend into Torbay Council area. The whole study area extends to just under 4km<sup>2</sup>. The study area boundary is included on the map below:



### 1.3 Flood Zone Allocation

The two watercourses are mapped by the Environment Agency (EA) as a Flood Zones (FZ). The upstream part of the southern catchment towards Higher Gabwell is not mapped as a flood zone.

An extract of the EA FZ map is included below:



The flood zone maps are produced using JFlow software and are based on the aerial radar data and the design flows discussed in Section 2.3. The programme assumes that the 2 year (QMED) flow is contained within the watercourse and all other flow is dispersed overland adjoining the watercourse.


These flood zone maps are also only as accurate as the radar data and in steep sided valleys can be very inaccurate.

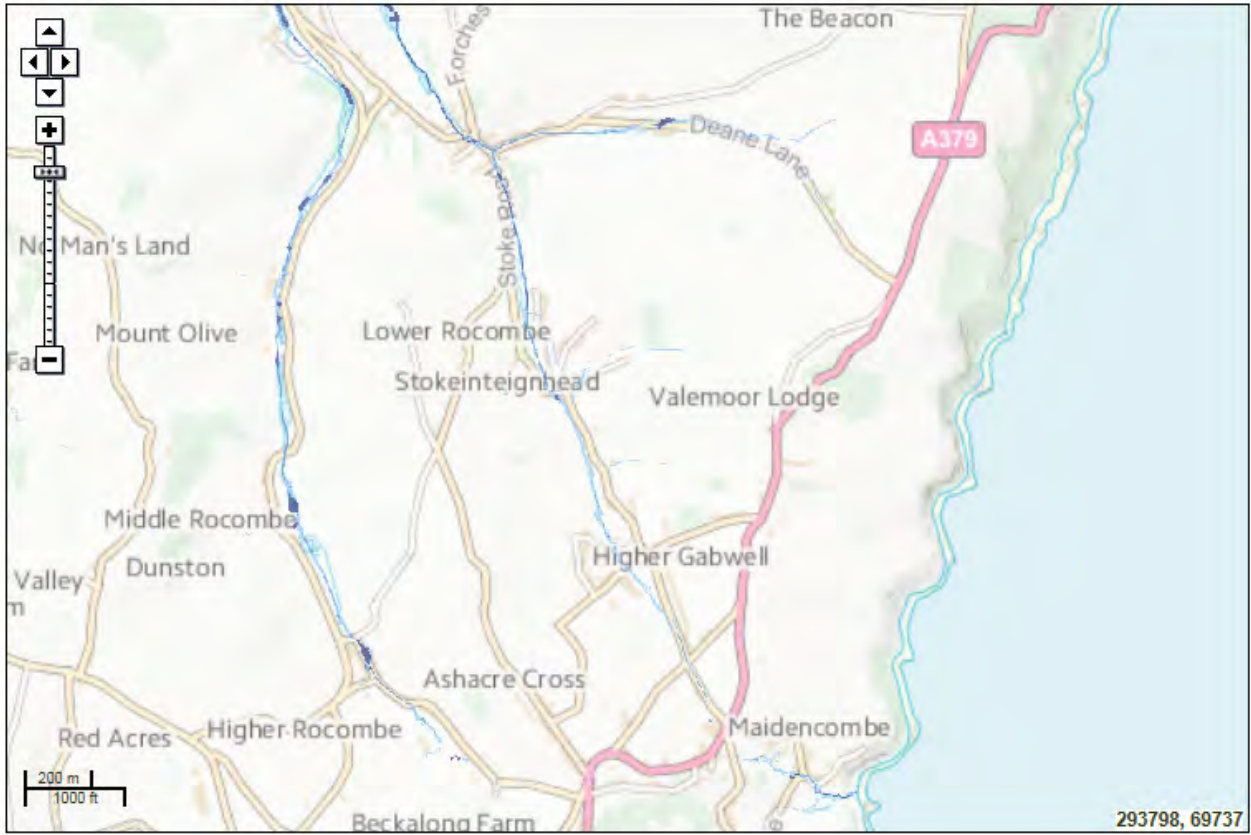
### 1.4 Surface Water Flood Risk Areas

The EA also map surface water flooding which is not necessarily related to a watercourse. These maps are more focused on topography, identifying valley features and flow routes during heavy rainfall. This map shows surface water flood risk as far south as Seaway / Greenbank on Stoke Road, Higher Gabwell. An extract of the map is included below with the larger scale version of the map included in Appendix A:





### Risk of Flooding from Surface Water

Map of X: 292,052; Y: 69,647 at scale 1:15,000

Data search 



**Map legend**

- Risk of Flooding from Surface Water
-  High
-  Medium
-  Low
-  Very Low

## 2.0 SOURCES OF INFORMATION

### 2.1 Devon County Council (DCC) information

DCC have provided the following information to assist the study:

- Digital height point data achieved by flying an area and bouncing a radar signal to ground. The time it takes for the signal to bounce back is then calibrated against the height of the aircraft and a ground level to Ordnance Survey datum is calculated on a grid of 5m spacing. These points can then be modelled to produce contours at any interval and used in catchment studies such as this. The data is the best available at present but is fairly coarse and accuracy is affected by tree cover and roof tops.
- Survey plan and sections of Stoke Cross and the watercourse channel and culverts between Victoria Farm and Five Blades including a new 600mm outfall pipe option;
- CCTV Survey data for the Stoke Road culvert and the upstream section in Deane Road;
- Stokeinteignhead Flooding Appraisal Causes and Alleviation Report of March 2014;
- Historic correspondence between Councillor Clarence and village residents;
- Plan showing 5 buddle hole locations. During the site walkover it was noted that there are other buddle holes within the study area, some are pipes and some are holes excavated through the hedge. Some of the buddle holes have been surveyed to assess the potential flow that would pass through until a point when flows exceed the approach channel and continue down the adjoining road. Each pipe surveyed has been given an approximate percentage value (i.e. 20%) to show the amount of the diameter from the invert that is used.

### 2.2 South West Water (SWW) information

SWW has provided the following information to assist the study:

- Extract of their public sewer records with cover and invert levels where known. A copy of the sewer records is included in Appendix A.

Other information on public sewer locations has been obtained from the SWW mapping website.

During the research for this study it was mentioned that Teignbridge District Council undertook an infiltration study for SWW to determine how much surface water was entering the foul sewer system. If this report is available it should be reviewed in conjunction with any potential flood alleviation measures to see if a collaborative solution to any of the sources of flooding can be achieved.

### 2.3 Hydrology

The hydrology flows in a 2 year and 100 year rainfall event were provided by the EA as part of the March 2014 report for the catchment at a location downstream of Five Blades (3.12km<sup>2</sup>). To supplement these additional rainfall event flows between the two storms were obtained from the EA. The full flows provided by the EA are as follows:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	2.16
Q2.33 (Mean Annual Flood)	2.45
Q10	3.67
Q25	4.85
Q50	5.99
Q100	7.14

Additional flows are required to determine the different standards of protection that can be designed for each part of the catchment being investigated. These design standards link into funding formulas at a later date when grants are being considered.

The flows can be proportioned back upstream to smaller sub catchment areas as part of any study. If an area is identified as a potential storage location the proportional flows can be determined and compared with various pipe sizes or throttle devices to see what flows could be stored temporarily and what flows can be allowed to continue downstream without any other improvements or with minor capacity improvements. Appendix C contains the flow calculations for various locations within the study.

The Flood Estimation Handbook (FEH) provides maps of watercourse catchments based on contours alone and these are what hydrology studies are normally based on. These maps make no allowances for hedge banks or other physical boundaries which might divert flow in or out of the contour based catchment areas.

For each sub-catchment area a hydrograph will be generated using the critical storm duration calculated in the FEH mapping. This will give a design flow in relation to rainfall every 15 minutes. These ¼ hourly flows can be used to calculate total volumes of runoff for consideration in flood alleviation measures.

## **2.4 Contour and Height Data**

The point data contained in the aerial radar survey has been converted to 1m interval contours for the study area using a software modelling package. The ground varies between 167m in the northeast, 140m in the south and 31m at Five Blades.

## **2.5 CCTV Survey Files**

The CCTV data includes information on pipe diameter and depth from ground level at manholes and gully gratings. This information is not related to any datum level.

A CCTV survey of the full pipe / culvert system between the Village Hall and the outfall at Victoria Farm has been undertaken. This shows the pipe is initially a 450mm, increasing to a 750mm pipe and then two different box culvert sizes. The system increases in size as it continues downstream but not necessarily in capacity as gradients are shallower in several sections of the 450mm pipe. The shallower pipe gradients mean the capacity is reduced by up to 50% compared with the inlet at the Village Hall.

A partial CCTV survey of the upstream end of the pipe / culvert system in Deane Road has been undertaken. This shows the pipe is initially a 375mm, expanding into a 620mm wide arch culvert. Further downstream the culvert becomes a 300mm pipe before increasing to a 450mm pipe and then a 750mm pipe. The 750mm pipe connects to the first of the box culverts in Stoke Road. The system decreases in size from the arch culvert to the 300mm pipe but becomes steeper in gradient. The steeper gradient does not however offset the reduction in size and the overall capacity is reduced by more than 50% compared with the 375mm inlet.

## **2.6 Utility Company Records**

The only utility company records reviewed to date are the SWW ones. Other utility company records should be obtained to determine any constraints on implementing flood alleviation proposals.

## **2.7 Level Survey Information**

Using the CCTV information each gully has been surveyed for level using the Ordnance Survey Benchmarks located on St Andrews Church and Mill Leat Farm. The gully locations have also been checked against the lengths quoted in the CCTV survey and corrected where appropriate.

Several SWW manhole levels have also been checked to confirm their records are correct.

Additional check levels have been taken around the village hall and along Deane Road to see how accurate the aerial height data is at this location.

The gully, pipe, culvert levels and locations have been input into WinDes software together with the pipe / culvert lengths and the existing pipe / culvert capacities calculated.

As a result of the walkovers a further pipe system in Lower Gabwell has been flagged up where tracing of pipes by a CCTV survey will be required to determine connections and capacities. Once this is carried out the additional gullies and any chambers located (buried or surface visible) will to be surveyed for level and the flow capacities calculated.

## 2.8 Flow Paths for Flood Water

During the walkovers the different overland flood routes have been investigated to determine where any flows leave or enter the catchment(s). Any gates, green lanes, hedge banks, paved areas, and roofs have been recorded where flows enter the highway or where the feature diverts water away from the natural flow route to the watercourse subsequently causing a concentration of flow which leads to flooding.

The walkover has also identified areas which are outside of the contour catchment in the FEH mapping, but when flow paths are considered at gates and along highway areas additional areas contribute flows into the study area. These are discussed in paragraph 3.3.

Using the contour survey information and walkover notes the fields, green lanes and other contributing areas have been measured off the Ordnance Survey maps so that an estimate of flows generated can be created.

In the site walkover the green lane surfaces were found to be compacted by agricultural traffic or consisted of compacted stone. When rain occurs these areas are flash flowing along the corridors between hedge banks until a gate or length of hedge with no earth base was found and then the flows have been witnessed travelling across open fields as a point source of flow. Where there are gates on the upslope side of these green lanes the fields above the lane also contribute flows into the green lanes.

Several of the properties adjoining Deane Road, Stoke Road and in Higher Gabwell have gravel drives and parking areas. Water has been witnessed running off these into the highway during moderate rainfall. This suggests that the parking or turning areas are also compacted and do not act as porous paving or soakaway blankets for very long in a rainfall event.

The locations of buddle holes identified on the DCC plan and by residents or parish members have been recorded on the drawings.

## 2.9 Catchment Runoff Percentage

The FEH also provides a Standard Percentage Runoff (SPR) factor for all soil types and catchments within the UK. These are the average for the catchment and are a combination of the Greenfield areas and urban areas (roofs, roads etc) and are what the EA use to produce their design flows included in paragraph 2.3.

The average runoff for both the watercourse catchments upstream of the village is 11.75% of area with an urban percentage of 0.84% upstream of Home Farm Court and 3.91% upstream of April Cottage. At The Mead in Higher Gabwell the urban extent is listed as 3.89%.

These **will not** take into account factors such as compaction on the green lanes or other areas compacted by constant trafficking as the FEH considers them as undeveloped Greenfield areas.

These compacted areas will be considered in the calculations of flow and flood attenuation areas, and to scope out any infrastructure improvements.

The Interim Code of Practice for SUDS (2004) gives guidance on the SPR for other different surfaces. The following table is reproduced from that document:

## 6.5 Contributing area

6.5.1 The criteria referred to above should be applied to the contributing surface area, and all runoff should be accounted for and evaluated, calculated as follows:

Surface	Impermeability factor (%)
Roofs: <sup>1</sup>	
– pitched roof	75–90
– flat roof smoothed surface	50–80
– flat roof with gravel or turf	40–50
Yards and paths	100
Roads, verges, and other highway land that may be compacted by engineering activity <sup>2</sup>	75–100
Gardens:	
– small gardens <sup>3</sup> with lawns and extensive paved area and hard standings	30
– large gardens (usually more than 0.1 ha)	10–20
Permeable paving systems:	
– asphalt and other smooth, dense pavements	85–90
– block pavements with wide joints	50–70
– gravel roadways	15–30
Fields:	
– naturally <sup>4</sup> draining to above	10–20
– cultivated, <sup>5</sup> fairly flat with moderate to good infiltration	10

For this study a range of alternative SPR have been used for the green lanes and gravel / compacted stone areas. In addition to the factors above the following have been included based on previous experience:

Green lanes	50% SPR
Compacted gravel drives	50% SPR

## 2.10 Highway Areas

The highway areas contributing to the gully systems in Forces Hill, Ivy Tree Hill, Deane Road, School Road and Stoke Road have been measured on site and calculated from Ordnance Survey Maps.

Other roads in the catchment area have been checked for gully systems. No road gullies could be located in Long Park Hill, Gabwell Lane, Gabwell Hill, Kirtons Road or the minor roads northeast of Gabwell House.

The additional gullies and their connectivity located in Lower Gabwell will be surveyed as part of the additional CCTV survey to be commissioned. The gullies on Stoke Road in Higher Gabwell will be investigated further with the owner of Higher Gabwell Farm.

The normal standard for highway drainage is to provide 1 gully for each 180 - 200m<sup>2</sup> of contributing highway areas. This equates to a flow of between 2.5l/s and 4l/s being able to enter the gully through the bars. The actual flow depends on the gradient and cross fall of the road. The area that these gullies actually drain is discussed later.

## 2.11 Planning Consents with Drainage Related Planning Conditions

A preliminary search of recent planning applications has been undertaken on the Teignbridge Planning Portal (TDC). A lot of the applicants state in their application forms that surface water drainage will go to soakaway. On many occasions however no further information was submitted with the application and no planning condition was applied to make relevant information available to be checked by TDC.

The walk through of the village has identified between 90 and 100 properties where surface water drainage from drives, roofs and paving areas discharges direct onto the highway. In excess of 11,500m<sup>2</sup> of roofs and paved areas have been identified. This increases the flood risk to the village. Some properties have been identified with specific planning conditions prohibiting discharge to the highway.

A list of the properties identified to date with approximate areas draining onto the highway is included in Appendix C. Further investigation of the planning files could be undertaken to see if other properties have similar planning conditions with the aim of reducing runoff to the highway and overall reduction in flooding. The agricultural areas and Green Lanes that contribute to the flood regime are discussed in paragraph 3.3.

## 2.12 Flood modelling parameters

To undertake any flood modelling a Manning value (Roughness index) for each channel type whether earth, stone or tarmac etc is required.

Estimates of channel and floodplain roughness were made during the site walkovers. The roughness values for vegetation have been used assuming it is the autumn / winter period when most flood events are likely to occur. The table below details the Manning values to be used:

Land Use/Area	Manning's n value
Grass, gardens, parks, pasture	0.035
Rough ground	0.1
Roads	0.017
Trees, hedges	0.08
Channel	0.02 - 0.04

### 3.0 CULVERT DETAILS, CATCHMENTS AND CAPACITIES

#### 3.1 Culvert and Pipe Details

Deane Road – the reach of culverted watercourse is 177m in length and consists of 1 culvert of varying size.

The culvert is of two different types:

- 1) Pipes of 300mm, 375mm, 450mm and 750mm diameter. There are two lengths of 300mm pipe, one length of 375mm diameter pipe, two lengths of 450mm pipe and one length of 750mm diameter.
- 2) An arch top culvert of 37m length. The arch is recorded as 620mm width in the CCTV survey but no height is given.

Stoke Road (Village Hall to Victoria Farm) – the reach of culverted watercourse is 335m in length and consists of 2 culverts of varying size and 2 open sections of watercourse.

The culvert is of two different types:

- 1) Pipes of 450mm and 750mm diameter. There are seven lengths of 450mm pipe, and three length of 750mm diameter pipe. This will be referred to as the upstream section going forward in the report.
- 2) One length of box culvert of 1250mm width by 500mm height and four lengths of box culvert 1375mm width and 625mm height. This will be referred to as the downstream section going forward in the report.

The open watercourse section is located at the end of the 450mm pipe opposite Rose Cottage. Flows split at the downstream end of the open channel between the 750mm pipe and bypass channel that flows around the Church House Inn. The bypass channel inflow is controlled by a sluice plate and only a nominal flow uses this route in dry weather conditions. The flow later rejoins the box culvert further down Stoke Road.

The Deane Road culvert joins the Stoke Road culvert 230m from the inlet near the village hall.

#### 3.2 Existing Catchment and Culvert Capacity Comparison

**Deane Road** – The catchment upstream of the 375mm inlet at Home Farm Court is 1.19km<sup>2</sup>. Based on the EA design flows the pro rata flows at the inlet are detailed in the table below:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	0.82
Q2.33 (Mean Annual Flood)	0.93
Q10	1.40
Q25	1.85
Q50	2.28
Q100	2.83

The capacity of the pipe system in Deane Road varies between 0.208 and 0.235m<sup>3</sup>/s (300mm pipe), 0.568m<sup>3</sup>/s (375mm inlet pipe), 0.542 and 0.638m<sup>3</sup>/s (450mm pipe) and 1.499m<sup>3</sup>/s (750mm pipe) showing that one pipe can accommodate a 10 year flow whilst all the others have less than the 2 year flow capacity.

It is not possible to accurately estimate the capacity of the arch culvert without the height and roof profile however based on 620mm width and the gradient it is likely to be around 0.5 – 0.6m<sup>3</sup>/s.

The CCTV survey has identified utility services crossing the top of the arch culvert which cause a restriction to flow. Based on the location these appear to be associated with water supply pipes to Home Farm Court. This should be investigated further as part of the capacity improvements so that any influence on the upstream storage design option can be assessed.

**Stoke Road** – The catchment upstream of the 450mm inlet at the village hall is 1.63km<sup>2</sup>. Based on the EA design flows the pro rata flows at the inlet are detailed in the table below:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	1.13
Q2.33 (Mean Annual Flood)	1.28
Q10	1.92
Q25	2.53
Q50	3.13
Q100	3.87

The capacity of the upstream pipe system in Stoke Road varies between 0.340 and 0.684m<sup>3</sup>/s (450mm pipe) and 1.321 and 5.066m<sup>3</sup>/s (750mm pipe) showing that two 750mm pipes can accommodate up to a 100 year flow whilst all the others have less than the 2 year flow capacity.

The capacity of the open channel section of watercourse opposite Rose Cottage is approximately 4.26m<sup>3</sup>/s. The inlet arrangement from the open channel to the first length of 750mm pipe is at 90 degrees to the flow and not very efficient which means the channel acts as flow storage for a significant part of the flow regime and although the potential capacity of the channel is greater than the 100 year storm the flow regime is governed by the outlet into the 750mm pipe and the second length of 750mm pipe which is much flatter. The first length of 750mm pipe has a theoretical capacity of 5.066m<sup>3</sup>/s under optimum flow conditions whilst the second length of 750mm pipe has a capacity of 1.321m<sup>3</sup>/s because of its flatter gradient. It can be shown that the open

The capacity of the downstream box culvert system in Stoke Road varies between 1.525m<sup>3</sup>/s and 3.119m<sup>3</sup>/s.

All these capacity assessments assume the pipes are clean with no debris and there are no obstructions crossing or blocking the pipe.

Between gullies 4 and 5 on Stoke Road there is another service pipe crossing the main flow. This installer of the crossing pipe has broken the top of the watercourse pipe to install their pipe and the CCTV survey estimates 20% loss of flow area has occurred. The damage appears to relate to a pipe from the dwelling called "The Rectory" adjacent to the school. The pipe is recorded on the SWW maps as a public sewer. An extract is included below; the full sewer records are included in Appendix A:



The capacity of the bypass channel around the pub has not been assessed as the inlet is controlled by a sluice board and the channel also passes under the pub itself. This channel could be investigated further to confirm the possibility of using it to convey flows however this may increase the flood risk to the rear of the pub where an entry door is located.

The WinDes software outputs from which capacities are estimated is included in Appendix D.

A similar exercise will be undertaken for the lengths of pipe and gullies in Lower Gabwell once the survey have been undertaken.

### **3.3 Culvert and Pipe Connectivity**

Using the WinDes capacity information a review of the efficiency of the pipe and culvert system has been undertaken.

The pipe system through the village centre consists of two pipe branches (Deane Rd and Stoke Rd south) which combine outside the Church House Inn and become a much larger box culvert.

The capacity of the Deane Road branch is between 208l/s and 1499l/s.

The capacity of the Stoke Road (south) branch is between 340l/s and 2567l/s.

The capacity of the box culverts is between 1967l/s and 3119l/s.

Each gully can add a flow of between 2.5l/s and 5.0l/s to the culvert system; we will use an average of 3l/s for comparisons based on the gradient of the road. This is far less than the flow runoff from the roofs and paved areas of between 18l/s and 61l/s depending on which storm is considered. Typically each 200m<sup>2</sup> of highway at this location will generate between 2.7l/s and 8.1l/s depending on which storm is considered.

In Deane Road the 300mm pipe between gully 1 and gully 2 has the 208l/s capacity. There are 3 gullies below the constricting pipe which can add a further 12l/s meaning the potential flow in the pipe could be 220l/s. The 450mm pipe has a minimum capacity of 542l/s and the 750mm pipe has a capacity of 1499l/s suggesting that the lower end of the pipe in Deane Road is not being utilised to its full potential.

In Stoke Road the 450mm pipe between gully 5 (outside school) and gully 6 (opposite Jasmine Cottage) has the 340l/s capacity. Further upstream the capacity is as high as 684l/s suggesting that flows will either fill the pipe using it as storage rather than being conveyed away. Flows may also surcharge the pipe system and exit gully 5 and run along the road. Downstream of gully 5 there are two further gullies, 6 and 7, where flows can enter the pipe system adding a further 6l/s. No other connections were identified in the CCTV survey. This means the pipe may only be conveying 346l/s compared with the capacity of 385-530l/s before it discharges to the open section of watercourse channel upstream of the Church House Inn.

The open watercourse now enters a 750mm pipe at right angles, the pipe has a steep gradient which WinDes suggests could have up to 5000l/s of flow through the pipe if the inlet arrangement and alignment was the most efficient possible. The next section of 750mm pipe has a capacity of 1321l/s meaning that this length of pipe is the governing factor in the inlet regime of the upstream 750mm pipe. The third section of 750mm pipe has a capacity of 2567l/s. No other connections to the pipe were identified in the CCTV survey. This means the downstream 750mm pipe may only be conveying 1321l/s compared with the capacity of 2567l/s before it discharges to the box culvert. A 150mm pipe connects at the manhole (6514) at the downstream end of the pipe; this may be a rainwater pipe as no gully is located nearby. A flow allowance of up to 10l/s has been added for comparison of capacity as we continue downstream.

The initial box culvert section downstream of where the two separate 750mm pipes join is 1250mm wide by 500mm high and has a capacity of 2064l/s. No other connections were identified in the CCTV survey. The combined flows from Deane Road and Stoke Road equate to 1677l/s (1321+346+10l/s) meaning again that the culvert is not being utilised to its full potential. A 400mm pipe is recorded in the CCTV survey as joining the system at the downstream manhole (5504).

The pipe has not been surveyed in the CCTV report but its level information is recorded by SWW. This relates to the watercourse that runs around the west side of the Church House Inn. A flow of 100l/s has been added for comparison of capacity as we continue downstream. Further survey work is required to determine actual flow regime around the rear of the church House Inn.

The next four sections of box culvert are all recorded in the CCTV survey as being the same size, 1375mm wide by 625mm high. The initial length of culvert has a capacity of 2288l/s; one connection was identified in the CCTV survey, this relates to a gully outside Bailey Farm. If no other branch flows join this length of box culvert a spare capacity of up to 508l/s may exist.

The next section of culvert has a capacity of 3118l/s. Two connections are shown in the CCTV survey, one from the west and one from the east in the direction of Forches Hill. There are two road gullies at the locations along the culvert and we have assumed that these are the contributing flows. Another pipe is shown connecting at the downstream manhole (5515) and again there is a gully located in the vicinity which we have assumed is the contributing flow. The potential flow from upstream and lateral connections is 1786l/s, or a spare capacity of 1332l/s.

The third section of culvert has a capacity of 2569l/s. A 225mm pipe is shown to connect from the west in the CCTV survey. There is a road gully at the location along the culvert and we have assumed that this is the contributing flow. The spare capacity is reduced at this location as the culvert becomes slacker in gradient. A separate surface water system of gullies, pipes and manholes joins the downstream manhole (5522). This serves development in Carlton Court.

The fourth section of culvert which becomes the watercourse through Victoria Farm has a capacity of 1525l/s based on the survey levels. This capacity may however be larger as there is an accumulation of silts at the outfall and the bed level may actually be lower and the capacity higher. Investigation of the depth of silt should be undertaken to determine whether there is actually a constriction at the outlet.

If there is a depth of silt and the final section of culvert has a capacity greater than 1800l/s there is spare capacity in the existing 750mm pipe and box culvert surface water system to accept more flow upstream in the vicinity of the Church House Inn. Removal of 100mm of silt and debris would lower the invert level and create double the capacity (3187l/s) in the final section of culvert.

### **3.4 Catchment Runoff Considerations**

We have already discussed the implications for additional runoff and flood routing from certain agricultural and paved areas of the study area. This runoff eventually ends up on the highway and is then routed into the village centre or flows pass through outlying settlements at Gabwell.

Using the height data, gate positions and anecdotal information some areas of the catchment, flow rates and volumes of runoff will be adjusted when the flood alleviation options are considered. The initial areas identified are detailed below with the location number corresponding to the area on drawings 421\SV3 – SV5; these may be expanded as further survey information is gathered:

#### **Deane Road catchment**

1. South of Deane Thatch – fields to the south of Deane Road stretching as far south as Higher Common Farm Barn discharge into the road as a single point flow. An approximate area of 8.23ha;
2. Flows can outflank the pipe or exceed the capacity of the pipe at the source of the watercourse. Flows then enter Deane Road off the field to the north which is 3.55ha. Some flows are captured by the gullies and routed back to the watercourse, however the road is cambered and some flows run along the north channel to Millen Lane junction;
3. Fields northeast of Millen Lane (6.84ha) drain onto Millen Lane (0.54ha) and are funnelled towards the orchard between hedge banks eventually running through the hedge into Deane Road;
4. Fields northwest of Millen Lane (8.53ha) stretching towards Butterfly Lane are funnelled by hedge banks and gates towards Deane House and Millen Lane (0.08ha);

5. Other agricultural paved areas, barn roofs and the access to Tickland Cottage in Deane Road contribute an area of 0.23ha. At Tickland Lane flows also run off the car park to the cottages built on the old village hall site and from the footpath that heads south towards the Green Lane to Higher Common Farm Barn (area 14).

In summary a concentrated flow will be considered at Millen Lane / Deane Road junction when assessing any flood alleviation measures.

### **Forches Hill Catchment**

6. Land at the junction of Butterfly Lane and Forches Hill drains onto the highway via a field gate. This can contribute an area of 1.24ha. This is one of the areas shown to be outside the catchment area in the FEH mapping;
7. Land adjoining Dagra Lane drains into Forches Hill. This can contribute an area of 0.54ha and is another area shown outside the FEH catchment mapping;
8. A buddle hole (Ref BH4) and field gateway between Teign Green and Teignharvey Road take runoff from the highway into the fields to the west. The crossfall of the road allows some flows to shed off the road, but at higher runoff rates the road crossfall and pipe diameter mean flows continue southwest towards Teignharvey Road. For now a flow a 20l/s has been allowed in the catchment adjustment figures based on the pipe alignment. Just south of this buddle hole the gateway on the west side of Forches hill has been regraded very recently; this now allows some flows to drain into the field rather than continuing downhill to Teignharvey Lane. The flows then cross the field to Teignharvey Lane and run away to the northwest out of the catchment. The road crossfall of Forces Hill at this location means that only a depth of 50mm can follow this route, deeper flows continue downstream to Teignharvey Lane junction. For now a flow of 10l/s has been taken into the catchment adjustment figures given the alignment of the gate to the flow path;
9. At the junction of Teignharvey Lane and Forches hill a gateway allows flows to run off the field to the northeast. This can contribute an area of 0.51ha. Teignharvey lane slopes away from Forches Hill and has a low point 35m northwest of its junction with Forches Hill so does not contribute any significant flow onto Forces Hill;
10. At Hillaway the drive, parking and field to the east run on to the highway; Hillaway paving and roof areas contribute up to 350m<sup>2</sup> with the field adding a further 0.17ha.

In summary a concentrated flow will be considered in the vicinity of Rock Farm when assessing any flood alleviation measures.

### **Ivy Tree Hill catchment**

11. Part of Ridge Road (compacted Green Lane) drains onto Ivy Tree Hill at Santa Rosa (0.38ha). There are two buddle holes in Ivy Tree Hill (Ref BH5 and another) but no further gullies to intercept flows. This means flows that exceed the buddle hole capacity end up outside The Lodge in Stoke Cross. The total highway area uphill of The Lodge that drains to Stoke Cross is approximately 1800m<sup>2</sup>. The area is served by 2 No 450mm diameter buddle holes, 7 gullies and a linear grated channel. No pipe system or manholes have been surveyed to date to show how the gullies are linked together underground. One of the buddle holes has an approach channel with good alignment and depth and would function at virtually 100% capacity, the second buddle hole probably has only 20% efficiency based on its alignment and depth. We have already discussed the two properties in Ivy Tree Hill that drain onto the highway.

In summary a concentrated flow will be considered at The Lodge when assessing any flood alleviation measures.

### **Stoke Cross area**

12. Flows from the roofs and paved areas of several dwellings run directly onto the highway. The falls on the paved area of Carlton Court are such that the runoff from the paved area misses the gullies constructed to catch the flows. Instead these run into the highway. A separate highway drainage system is located between Lilac Cottage and Carlton Court. This collects runoff from Ivy Tree Hill, Carlton Court, Forches Hill and Stoke Cross. The system consists of gullies, a linear channel and a 225mm outfall pipe to the watercourse through the grounds of Victoria Farm. The outfall was surveyed for the original flood study report and found to be 43.4m in length and have a capacity of 54l/s. This has been checked in WinDes with the length and fall of the pipe input to confirm capacity; the result shows a capacity of up to 62.4l/s.

In summary a concentrated flow will be considered in conjunction with Ivy Tree Hill catchment at The Lodge when assessing any flood alleviation measures. The existing 225mm pipe outfall will be included in any revised flow regime considered.

### **Church Lane catchment**

13. Runoff enters Church Lane from the southwest up above St Andrews Church where the land rises to meet Ridge Road (location 11). The roofs and parking areas of at least 4 dwellings and the path to the church drain onto the highway. There are no highway gullies to accept these flows so runoff reaches Stoke Cross area. Church Lane uphill of Na Mara contributes at least 0.09ha of flow from the compacted green lane. The surfaced part of Church Lane is approximately 330m<sup>2</sup>. Other flows run off the fields into Church Lane but the exact quantum has not yet been established as there are no obvious gates, or other flow paths evident from the walkover. Excavation of an access track has been undertaken at the southern end off Church Lane which alters the natural shed of runoff. This is not picked up on the LIDAR and should be investigated in more detail with the other fields between Ridge Road and Church Lane to determine any less obvious flow paths.

In summary a concentrated flow will be considered at Rose Cottage when assessing any flood alleviation measures

### **Stoke Road – Lower Gabwell catchment**

14. Runoff enters Stoke road off the green lane from Higher Common Farm Barn opposite April Cottage. The lane catchment area is 0.45ha with additional flows from the adjoining field areas of up to 2.91ha. This flow has a lot of suspended solids and silts which enter the highway and run north through the centre of the village. The existing gullies are overwhelmed by the flow depth and width which stretches to the full width of the highway. A silt trap is being considered at this location to intercept the debris;
15. Further south past the village hall at Gabwell Cross runoff from agricultural land and the unnamed road to Ridge Road join Stoke Road from the southwest. 0.96ha of agricultural land and 1825m<sup>2</sup> of highway flow into Stoke Road and continue down to April Cottage. Two gullies are located on the junction but we have been unable to find the outfall. A buddle hole between Briar Cottage and the village hall takes some flow off the highway and pipes the water across the village hall car park to the watercourse;
16. Continuing south along Stoke Road. Between Honeycombe Cottage and Marden another agricultural track joins the highway from the west. Flows are reported to cross Stoke Road to the east and flow into gullies and a buddle hole west of The Firs. Flows cross the field and join the watercourse. No reports of property flooding were received in the walkover and site meetings so the catchment to the west has not been investigated to date in any depth.

In summary a concentrated flow will be considered in the vicinity of the village hall when assessing any flood alleviation measures.

### **Lower Gabwell area**

17. In Lower Gabwell overland flooding has been reported entering The Knut House from the northeast. The problem has increased since the redevelopment of the former Pinks Nursery (Now Hollifields). Landscaping and paved areas have been undertaken as part of the planning consent. Surface water runoff was noted as to soakaway in the application form and on outline drawings. In the planning consent Condition 3 required submission of surface and foul water drainage details. An inspection of the planning file for this property is recommended to see what information has been submitted and whether the soakaways have been designed to appropriate standards.
18. The locals have advised that the watercourse upstream of Hilary Cottage for 140m is underground in twin 150mm pipes. The exceedance flows run off the fields and enter the highway east and west of Hilary Cottage. Some flows enter the highway gully system and a pipe network which reappears downstream at The Firs. The pipe is of varying size, 300 and 375mm pipes have been located. This system requires further investigation to determine the route and capacity. Once these are known the upstream attenuation options can be investigated in detail. The watercourse is in open channel upstream of the twin pipe inlet (opposite Sunny Bank) so all flows off higher land reach the inlet of the twin 150mm pipes, there is no major flow diversion route or adjustment of the catchment at this location.
19. There is a gully and pipe system in the highway between Sunny Bank and Hilary Cottage. The gullies were blocked when the walkovers occurred and locals advised that the size of pipes was unknown. These gullies may connect into the system that starts at Hilary Cottage and should be investigated when the CCTV survey is commissioned. If the gullies and pipe system functioned as designed it would reduce the volume of overland flow reaching Hilary Cottage that sheds off fields to the east adjacent to Sunny Bank;
20. Further flows enter the highway at Orchard Organic barn, direct off the compacted gravel track and through the hedge bank off the fields.

In summary a concentrated flow will be considered between Hilary Cottage and downstream of The Mead when assessing any flood alleviation measures.

### **Higher Gabwell area**

21. In Higher Gabwell there are various side roads without any highway drainage system or public sewers. As a result flows from dwellings, paved areas and the highway run along the highway to the valley bottom and watercourse. In Kirtons Road, Gabwell Lane, Gabwell Hill, Stoke Road and Longpark Hill there are many properties that have no surface water drainage management of runoff from their drives with all flows entering the highway. On Stoke Road opposite Appleshaw 2 buddle holes have been created to allow flows to run across the fields of Higher Gabwell Farm to the watercourse. A number of highway gullies have also been located along this stretch of road but no outfall could be found in the walkover;
22. Near Longpark Hill the watercourse and catchment enters Torbay Council area. There are two blocks of land between Longpark Hill, Stoke Road and the A379 Teignmouth Road which drain onto Stoke Road. The total area is 1.74ha. There also 3 properties (Crossways, Greenbank and Seaway) that drain significant areas of paving onto the highway. All the dwellings are located high above any flood flow that runs along the highway and there have been no reports of property flooding received during the study investigations in the Torbay area.

In summary, as there have been no reports of property flooding the only action would be to investigate the function of the existing highway gullies and buddle holes in Stoke Road.

### **3.5 Summary of catchment runoff and flood sources**

All of the areas investigated above create some runoff that enters the highway and is then conveyed toward residential dwelling areas. The most significant areas of agricultural and paved area runoff that create the most flooding to property are located in:

- a) Deane Road;
- b) Forches Hill;
- c) Ivy Tree Hill / Stoke Cross/ Church Lane;
- d) Stoke Road (April Cottage area);
- e) Lower Gabwell (Hilary Cottage – Sunny Bank);

No flooding of property has been reported during the study for the length of Stoke Road between Gabwell Hill/Lane and Longpark Hill.

When undertaking the walkover the only property identified in Higher Gabwell that may be at risk of flooding is in Kirtons Road. This is Badgers Brook (was Ryecroft).

These 5 areas of runoff will form the basis of the flood alleviation options to be investigated that will reduce flood risk to residential property.

### **3.6 Watercourse Channel Size and Capacity**

Both the watercourses upstream of the village are of varying size and section and have not been surveyed in any detail to date. This will be undertaken as part of the next stage of the flood alleviation study once locations have been identified for potential flood alleviation works.

A cross section of the stream has been surveyed at the upstream end of village hall building to determine the capacity of the watercourse in relation to the 450mm inlet pipe.

At the location of the section the stream has a capacity of approximately 5.2m<sup>3</sup>/s compared with the pipe inlet which has a capacity of 0.68m<sup>3</sup>/s.

### **3.7 Silt Content of Overland Flows**

One of the major problems of the flood flows is that they contain a large amount of silt and other debris washed off the green lanes. This mobile load is deposited in the highway in several locations and also fills gullies where they have silt trap sumps. In Deane Road and Stoke Road the gullies mainly have a through flow from the watercourse and have no sumps below the pipe invert. The flows and capacities calculated in WinDes assume that the flows are water with minimal debris.

As part of the detailed design a number of silt traps, interception ditches and settlement basins will be investigated.

## 4.0 FLOOD ALLEVIATION OPTIONS

### 4.1 General discussion

During the site walkover the valley features of the watercourse were assessed for potential storage locations. A simple dam option together with excavation of soil locally to construct the bund across the valley identified 3 potential locations to hold flows back. These are below Deane House, on land between the village hall and Pools Weir Road and between The Mead and Hilary Cottage.

At Deane House there is an existing pond that could be incorporated into the storage.

At Pools Weir there was a pond which was used to collect water to feed a leat system. The pond appears on the 1954 Ordnance Survey 1:2500 map.

The level point data has been processed to create 0.25m contour information for assessing each of these three locations. The accuracy of this data is however very coarse and detailed topographical survey work will be required to progress any of the detailed design options.

The cross section at the village hall identified that the contour data from the digital height points can be up to 2.0m different to the levels take from the Ordnance Survey benchmarks.

### 4.2 Deane Road

There are various options to alleviate the depth of flood flow along Deane Road including:

- 1) Creating some upstream storage near the old pond south of Deane House and reprofiling the crossfall of the road to direct flows into an enlarged pond. This will manage the flows upstream of the residential area of Deane Road rather than allowing flows to travel downstream;
- 2) Creating interception ditches in the orchard south of Deane House with a throttled pipe outfall to the watercourse. This will introduce some control of the flows shedding off Millen Lane and fields to the north;
- 3) Enlarging the existing watercourse pipe or construct an oversized public surface water sewer along Deane Road to accept the flows from all the properties that currently drain onto the highway. This would allow the existing gullies and watercourse to convey highway runoff and the watercourse;
- 4) As 3) above but include some of the highway area. This would allow the existing pipe to convey more of the throttled watercourse flows from 1) above
- 5) Smaller works such as adding additional gullies and buddle holes will also benefit the depth of flooding although this will only remove an average of 3l/s of flow per gully.

The catchment flows at the pond were recalculated using the EA data and the additional flows that shed off Millen Lane and the land to the northwest of Deane House, this increased the flows by around 13% overall. For the storage assessment we have assumed that these flows will be captured using cut off ditches and directed into the storage area by pipe or open channel. The adjusted flows used for Deane House are in the following table:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	0.825
Q2.33 (Mean Annual Flood)	0.936
Q10	1.402
Q25	1.853
Q50	2.289
Q100	2.832

The existing pipe run in Deane Road varies in size between a 300mm pipe and a 750mm pipe with capacity between 208l/s and 1498l/s.

The runoff from the area of highway and the additional roofs draining onto the highway has been assessed. A road length of 266m of road (Millen Lane to Braeburn Cottage) at an average width of 5.5m (1463m<sup>2</sup>) has been used together with a net area of 1310m<sup>2</sup> of roof and paving. The flowing flows have been calculated:

Return Period	Highway area flow 1463m <sup>2</sup> - (l/s)	Highway and property area flow 2773m <sup>2</sup> - (l/s)
Q2 (QMED)	19.8	37.5
Q2.33 (Mean Annual Flood)	22.5	42.5
Q10	33.6	63.7
Q25	44.5	84.2
Q30	47.2	89.3
Q50	54.9	104.0
Q100	67.9	128.6

From this the proportion of flows from highway and property that utilise the culvert can be seen compared to the 300mm pipe capacity of 208l/s.

The runoff from the highway and property has 4 opportunities to join the flows in the culvert via the existing gullies. Typically a gully is designed to accommodate flow from an area of 200m<sup>2</sup>. Each gully along Deane Road is expected to deal with flows of 693m<sup>2</sup>.

#### Option 1 – Upstream storage

A preliminary assessment of the valley upstream of the pond has been undertaken using the contour information.

To test the volumes of potential storage required the 50 year flow generated by the highway and property area from the table above has been deducted from the lowest capacity of the 300 pipe section. This leaves a flow of 104l/s which might discharge from the attenuation upstream without overwhelming the pipe system in Deane Road. The 104l/s is the approximate runoff that SWW would expect their pipe system to be designed to accommodate based on the contributing areas of highway, roof and paving.

Using the hydrograph flows generated earlier a value of 104l/s has been deducted from each time interval to represent the flow that can be released to join the flow contribution from Deane Road and property below the location of the storage area. This leaves a range of values between 0 and 2.728m<sup>3</sup>/s to calculate the runoff volume for.

Using a spreadsheet the potential volumes of runoff in the 25yr, 50yr and 100yr critical storm are calculated as 11835m<sup>3</sup>, 14,837m<sup>3</sup> and 18,616m<sup>3</sup>.

Using the height data and contours a sketch layout has been developed showing how much land and excavation would be required.

The initial design has tested a dam 5m high constructed across the valley between the 49m contour values and an invert of 44m. The upstream and downstream faces of the dam has been graded at 1 in 3 slopes with the side of the valley being regraded to 1 in 5 slopes. The footprint area of the dam is 1625m<sup>2</sup>. The upstream valley area regraded to 1 in 5 has an area of 4150m<sup>2</sup>. This has provided a storage volume of 11420m<sup>3</sup>, just short of the 25 year storm volume calculated above. This layout is shown on drawing 421\SV6. An alternative layout could be to provide two smaller linked basins that provide a larger volume and allow flows to cascade through them.

The dam faces can continue to be used for grazing at the 1 in 3 design slopes. The valley upstream can also continue to be used for grazing and at 1 in 5 slopes the grass can be cut with mechanical equipment. The existing field has slopes up to 1 in 6 at present.

To progress a more detailed design a topographical survey should be undertaken. Once the detailed survey information is available the footprint and volume can be worked up in more detail to whatever standard of protection is deemed appropriate.

The outflow from the storage area could be increased and the volumes of storage calculated could be adjusted downwards as it takes approximately 40 minutes duration in the 100 year storm for the upstream catchment to respond with the flow rate of 104l/s. During this time the bulk of the road and roof areas should have already drained away leaving additional spare capacity within the culvert. This assumes that there is one storm and it passes, if a second intense rainfall event occurs within 30 minutes then this option would mean surcharging of the existing pipe under Deane Road. An assessment of this risk will be undertaken in the detailed design.

#### Option 2 – Interception ditches in the orchard south of Deane House

The current flow regime has overland flow discharging from Millen Lane and land to the north directly into Deane Road. The optimum location to install cut off ditches is in the orchard and field immediately east of Deane House.

A buddle hole in Millen lane to the northeast of Deane House would be needed to connect the flow from the catchment to the northwest of Millen Lane to the cut off ditch.

Additional buddle holes along Deane Road between the Orchard and commercial buildings to the east could also be provided to take runoff from Deane Road into the attenuation area.

The detailed design and flow discharge rates of these areas will need to tie into the attenuation designed under Option 1 with any volumes in the cut off ditch contributing to the total volumes of storage required.

All these potential flood alleviation features are included on drawing 421\SV6.

#### Option 3 – Enlarging the existing watercourse pipe or construct an oversized public surface water sewer along Deane Road

There are two sections of 300mm pipe which have significantly less capacity than the other lengths. These should be investigated to determine whether they can be enlarged or twin parallel pipes installed if other utility services are a constraint. A larger 450mm pipe would provide similar capacity to the rest of the system and allow additional flows from the upstream storage area to be released.

The existing dwellings and paved areas that drain into Deane Road could be connected to a new public surface water sewer. This would be in conjunction with SWW and would draw on the infiltration survey undertaken by Teignbridge. If SWW have identified existing surface water runoff areas that connect to their foul sewer these could be removed and added to the areas identified in this study that contribute to flooding in Deane Road.

The contributing flow from the 1310m<sup>2</sup> roof and paved has been deducted from the calculations included in Option 1. This allows the flow from the attenuation area of Option 1 to be increased by 49l/s to 153l/s. The result of this is that the volumes of attenuation reduce to 11161, 14149, and 17917m<sup>3</sup> in the 25yr, 50yr and 100yr critical storms; an average reduction of 687m<sup>3</sup> of storage.

If a 300mm pipe was laid at a similar gradient to the existing watercourse of 1 in 27 it would have a capacity of 214l/s; i.e. over three times that needed for the roofs and paved areas identified to date in this study. The pipe would start near The Brook / Orchard House and connect to SWW MH6511 outside Bramley Cottage. The downstream 750mm pipe and box culvert system has adequate capacity to accommodate this additional flow.

The delivery of this pipe would rely on a route being available through other utility services within Deane Road although there is over 6m of fall between Brook Cottage and Bramley Cottage. There is an existing 150mm diameter SWW foul / combined sewer that runs along the preferred route of

any new surface water sewer. If this is a constraint a shorter length of pipe could be delivered from MH6511 working upstream if a clash with this or any other services is identified.

#### Option 4 – As option 3 with highway areas

This option would be the same as option 4 but would also include the provision of additional road gullies connected to the additional or enlarged pipe.

Deane Road varies between crossfall and camber along its length. At present all the gullies are located on the south side of the road except for the one at The Old Bakery. Where lengths of the road have camber with the highest point in the centre of the road the additional pipe and gullies would remove flows from the watercourse culvert freeing up potential to release more flow from any upstream storage area.

To determine the suitable areas a detailed topographical survey of Deane Road will be required that picks up each channel and the centre line level every 10m along the road.

#### Option 5 – Smaller works

Spare capacity has been identified in some lengths of the surface water system. Additional gullies installed in Deane Road would remove flows from the highway, roof and paved areas.

An additional buddle hole between Deane House and the commercial buildings at location 5 would remove some flows off the road. The location should be chosen based on the crossfall or camber of Deane Road. The pipe flow would be connected to the storage area via shallow ditch.

#### Summary of options

The following table summarises the above options. The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. Costs will be added at a later date once survey work and further design is completed:

<b>Location &amp; Option</b>	<b>Brief description</b>	<b>No properties benefitting</b>	<b>Budget Costs £k</b>
Option 1	Upstream storage	21 – 25	-
Option 2	Interception ditches	11 – 15	-
Option 3	Ex pipe enlarged or duplicated for property connections	16 – 20	-
Option 4	Ex pipe enlarged or duplicated for property and highway connections	16 – 20	-
Option 5	Small works: Additional gullies Buddle Holes	11 – 15	-

### **4.3 Forches Hill**

There are very few options to alleviate the depth of flood flow along Forches Hill compared with other locations. The steep topography and no natural valleys mean the following are probably the main areas for further investigation:

- 1) Creating a new pipe and gully system to intercept all the flows that run from as far north as Butterfly Lane. This could include some attenuation and would be connected to the box culvert system in Stoke Cross near Victoria Farm. Connection of the existing road gullies could also be undertaken if they are found to connect to the SWW foul sewer. Existing property roofs and paving in Forches Hill estimated at 757m<sup>2</sup> that currently discharge to the highway would also be connected to the new pipe system;

- 2) Creating interception ditches in the vicinity of Teignharvey Lane to store some of the runoff emanating from the area north of the junction with Forches Hill. There is a natural low spot in Teignharvey Lane adjacent to location 9 which could be used to funnel flows into linear storage features to the west. The photograph below shows the area:



These could either be just storage relying on infiltration to empty or have a ditch or pipe outfall to the Arch Brook to the west. This would still leave the area of Forches Hill to the south (1000m<sup>2</sup>) and the Hillaway catchment contribution to consider under Option 1;

- 3) Smaller works such as adding additional gullies and buddle holes will also benefit the depth of flooding although this will only remove an average of 3l/s of flow per gully. Additional buddle holes may be difficult to achieve as it has been reported that the landowner on the western side of Forches Lane near Rock Cottage blocks the existing buddle holes to prevent runoff entering their land.

The catchment area of Forches Hill between Rock Cottage and Butterfly Lane, Dagra Lane and fields either side of Forches Hill that feed into the highway have been calculated and adjusted for the buddle holes and gate flow paths identified that remove flow off the highway. 30l/s has been deducted from all the flows calculated.

The table below shows the flows that have been calculated:

Return Period	All areas: Highway, fields, roof and paving 6230m <sup>2</sup> - (l/s)
Q2 (QMED)	54.4
Q2.33 (Mean Annual Flood)	65.9
Q10	113.9
Q25	159.9
Q30	171.4
Q50	204.0
Q100	259.6

#### Option 1 – New pipe system

Applying the same design standard of 1 in 50 years and using the gradient of Forches Hill which is an average of 1 in 8.5 based on the height data contours a pipe of 300mm diameter is required to accommodate a flow of 204l/s.

Flows could be collected at Teignharvey Lane in a ditch feature from the higher part of the catchment before being discharged into a new pipe. New gullies would be located along Forches Hill to collect the highway runoff. Connections from each property roof and paved area could be made direct to the sewer via manhole chamber.

#### Option 2 – New interception ditch and outfall pipe system

A linear ditch feature excavated parallel with Teignharvey Lane could be 75-80m in length running along a contour. It would only provide a modest volume of storage compared with other flatter locations in the village. If the ditch were 80m in length with a 2m wide invert and 1 in 2 side slopes the maximum volume available would be 320m<sup>3</sup> and it would take around 45 minutes to fill in a 10 year storm or 25 minutes in a 50yr storm without any outfall pipe or ditch.

The SPR ratio for the catchment of 11.75% indicates that the soils are fairly permeable in nature and that some infiltration is achievable. To investigate this option further BRE365 soakaway tests will need to be undertaken in the location of the potential ditch feature.

An outfall ditch or pipe to the Arch Brook to the west would be set slightly above the invert of any linear ditch feature so that silts and debris were retained in the ditch. The silts would reduce the infiltration potential over a period of time. This layout is shown on drawing 421/SV7.

#### Option 3 – Additional gullies and buddle holes

Based on the historic flood regime this option will not be sufficient as a standalone solution but would assist in removing some flows from the highway before it reaches Stoke Cross and the properties located there.

#### Summary of options

The following table summarises the above options. The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. Costs will be added at a later date once survey work and further design is completed:

<b>Location &amp; Option</b>	<b>Brief description</b>	<b>No properties benefitting</b>	<b>Budget Costs £k</b>
Option 1	New pipe system	11 - 15	-
Option 2	Interception ditches & outfall pipe	11 – 15	-
Option 3	Small works: Additional gullies Buddle Holes	6 – 10	-

#### **4.4 Stoke Cross / Church Lane / Ivy Tree Hill**

The source of flooding considered under this section is from Ridge Road, dwellings on Ivy Tree Hill, highway areas of Ivy Tree Hill and Church Lane. Other sources of flooding in Stoke Cross are assessed elsewhere.

There a few options that can be considered that will reduce the risk of flooding at this location. The main solutions are:

- 1) Extending the existing highway drainage system further northwest up Ivy Tree Hill from its current location at Lilac Cottage. This would include oversized pipes and additional gullies;
- 2) Constructing a new oversized surface water sewer between Fir Tree Cottage and Lilac Cottage to take flows from Golden Dawn and Fir Tree Cottage and the highway area;
- 3) Additional pipe connection from the highway gullies and channel drain to the box culvert system to allow additional flow over and above the capacity of the existing 225mm pipe to be removed from the road surface;

- 4) The fourth section of box culvert through Victoria Farm has an accumulation of silts which impacts on capacity. Investigation of the depth of silt and the SWW sewer levels should be undertaken to determine whether there is actually a constriction at the outlet;
- 5) Creating a new pipe and gully system in Church Lane to intercept all the flows that run off property and highway areas. A connection to the existing box culvert system would be constructed as an outfall;
- 6) Provision of a larger or additional outfall pipe parallel to the existing 225mm highway outfall pipe;
- 7) Formalise buddle hole 5, construct additional pipes and gullies and create an outfall to the Arch Brook downstream of Grange Vale.

The catchment area of Ridge Road, Ivy Tree Hill and paved / roof areas of property that reach The Lodge have been calculated. 30l/s will be deducted from all the flows calculated for Ivy Tree Hill area as it is considered these flows could utilise the buddle holes. The area of Church Lane has also been assessed in the same way. The table below shows the flows without adjustment that have been calculated:

Return Period	Ridge Rd & Ivy Tree Hill areas: Highway, roof and paving 4099m <sup>2</sup> - (l/s)	Church Lane – all areas – 1008m <sup>2</sup> (l/s)
Q2 (QMED)	55.5	13.7
Q2.33 (Mean Annual Flood)	63.1	15.6
Q10	94.6 (64.6l/s adjusted)	23.4
Q25	124.9	30.8
Q30	132.4	32.7
Q50	153.9	38.0
Q100	190.5	47.0

From these figures it can be seen that the existing 225mm pipe is just about adequate to accommodate flows from the 10 year storm for the whole contributing area of Ridge Road, Ivy Tree Hill and properties. The problem is that the number of gullies and other piped connections are insufficient to connect to the 225mm pipe and silt and debris blocks some of the gullies and linear channel.

#### Option 1 – Extended highway system

7 gullies have been located in the area of highway under consideration. This would account for up to 1400m<sup>2</sup> of highway if the normal design standards are applied. The calculation shows that an additional 2 gullies would be needed for the highway area alone.

If the whole area including Ridge Road and properties are added the contributing area after factoring increases to 4099m<sup>2</sup>. This would mean a further 10 or 11 gullies are needed if the flow allowance for the buddle holes is deducted. A pipe of 175m length would be required, starting from around the area of Fir Tree Cottage, below buddle hole 5 and joining the existing highway system if it has capacity. To confirm this the lengths of pipe between gullies should be surveyed for size and capacity calculated to see if additional upstream gullies and pipes can be added to extend the system.

If insufficient capacity exists a larger scheme with additional pipe length would be required or the pipe could be constructed oversize to provide some attenuation of the flow before it joins the existing system.

### Option 2 – Additional surface water sewer

This would be similar in layout to the highway only system but would include purpose built connections for the properties in Ivy Tree Hill and Stoke Road. The paved area or roof of each dwelling would connect to the sewer via a new manhole or pipe link. The pipe would be constructed in conjunction with SWW.

The new pipe would connect to the existing box culvert system outside Victoria Farm at MH5521 or MH5522. The pipe could be oversized to store flows,

The delivery of this pipe would rely on a route being available through other utility services in Stoke Road.

### Option 3 – Additional pipe connection

The 225mm pipe outfall from the highway drainage system has a capacity of circa 62l/s compared with the flow of 154l/s from the Ivy Tree Hill catchment area in the 50yr storm. An additional pipe connection between the highway drainage system and MH5521 or MH5524 could be provided to divert exceedance flows. The CCTV survey did not open MH5521 or MH5524 to confirm depths, connectivity and capacity. These chambers should now be opened as part of the next round of surveys to confirm the feasibility of this option.

### Option 4 – Silt accumulation and SWW sewer pipe crossing

Investigate the depth of silt and the falls on the existing SWW sewer pipe that crosses the watercourse near Five Blades and Victoria Farm to determine whether there is scope to adjust the pipe levels. An extract of the SWW records showing the sewer location is included in Appendix A.

### Option 5 – Additional surface water sewer in Church Lane

There are 3 dwellings at the head of Church Lane which drain onto the highway. Overall up to 1008m<sup>2</sup> of area is estimated to drain into Stoke Cross from this location. A new pipe and gully system would collect the runoff from the highway and properties. A short length of pipe (20m) starting outside Rose Cottage with road gullies would be connected to the box culvert system at MH5505. This would remove the flood flow contribution from this source before it reaches Stoke Cross. The pipe could be oversized to store flows if space permits around other underground utility services.

### Option 6 – Larger or additional pipe outfall through Victoria Farm

TDC have previously investigated this option and an outline scheme showing a 600mm pipe was produced. The design produced replaced the existing 225mm highway outfall pipe increasing the capacity to around 730l/s.

This option will require many new gullies connections and feeder pipes to maximise the full flow capacity. These would be located between Carlton Cottage and Lilac Cottage. The box culvert at MH5522 outside Victoria Farm has approximately 400mm of cover to the top making it too difficult to run pipes over the top of it to Forches Hill. If pipes are laid under the culvert they would be too low to achieve the outfall levels in the watercourse.

There is also an existing combined sewer that runs parallel from MH5513 to MH5519 before turning north to run parallel with the watercourse through Victoria Farm. A further branch of the sewer serving Carlton Court also crosses Stoke Cross from south to North. Again the depths of these pipes will make it difficult to lay a new pipe towards Forches Hill.

Two private connections running from west to east under the Mews, adjacent to The Lodge have been identified by the owner. These drain the low lying area outside the Mews and are fed by flows off the highway to the south. They connect to the watercourse and would need to be surveyed in to make sure they were not compromised by any new pipe that replaces the existing 225mm pipe.

Victoria Farm and part of the existing garden wall under which the 225mm pipe passes are Grade II listed structures. Any alterations or works under the wall may require the approval of English Heritage.

This option as a standalone relies on flows arriving from Ivy Tree Hill and Stoke Road/Forches Hill. As such there would be no benefit to properties in other areas of the village where flows will continue to run past or into the dwellings. This option as a standalone would deal with a very local area of flooding but would not address the wider issues, leaving the majority of properties further up the village at risk with no benefit.

This option should be revisited once any upstream improvements have been costed and the existing utility records checked. If funding is sufficient and utility locations are favourable a smaller improvement could be implemented. This option alone does not provide a large cost to benefit ratio when assessed against the wider flooding in the village.

#### Option 7 – Additional outfall at buddle hole 5

This buddle hole has an approach channel which is deep and enables the full diameter of the pipe to be utilised. The road crossfall could be adjusted slightly with overlay to shed the flows from Ridge Road and highway upstream through the buddle hole. Downstream of the buddle hole a new ditch could be created to convey the flows to the Arch Brook. If the ditch is run along the natural contour in the middle section the flows can be encouraged to drop their sediment load out before discharging to the watercourse. A sump or low spot in the vertical alignment lower than the ditch invert could be utilised as a silt trap feature. This would need cleaning out at a frequency to be determined. This layout is shown on drawing 421\SV7.

#### Summary of options

The following table summarises the above options. The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. Costs will be added at a later date once survey work and further design is completed:

<b>Location &amp; Option</b>	<b>Brief description</b>	<b>No properties benefitting</b>	<b>Budget Costs £k</b>
Option 1	Extend highway drainage up Ivy Tree Hill	11 – 15	-
Option 2	Extend SWW sewer up Ivy Tree Hill	11 – 15	-
Option 3	Additional connection between highway system and box culvert	11 – 15	-
Option 4	Remove silt accumulation and investigate SWW foul sewer levels	21 – 25	-
Option 5	New public sewer from Church Lane to box culvert	11 – 15	-
Option 6	Enlarge existing 225mm pipe through Victoria Farm	11 – 15	-
Option 7	Extend outfall of buddle hole 5	11 – 15	-

#### 4.5 Stoke Road & School Road (Village Hall to Deane Road)

There are various options to alleviate the depth of flood flow along Stoke Road and School Road including:

- 1) Creating some upstream storage between the village hall and Pools Weir. There is an old pond shown on the 1954 OS 2500 map between Briar Cottage and The White House. The location could be used to create a dam and pond arrangement similar to Deane Road Option 1. This will manage the flows upstream of the residential area of Stoke Road rather than allowing flows to travel downstream;
- 2) Creating buddle holes and interception ditches in the field east of the village hall with a throttled pipe outfall to the watercourse. This will introduce some control of the flows and remove mobile sediment shedding off the green lane that starts near Higher Common Farm Barn and the fields to the east that flow into the green lane;
- 3) Construct an oversized public surface water sewer along stoke Road to accept the flows from all the properties that currently drain onto the highway. This would allow the existing gullies and watercourse to convey highway runoff and the watercourse only;
- 4) As 3) above but include some of the highway area by constructing additional gullies. This would allow the existing pipe to convey more of the throttled watercourse flows from 1) above;
- 5) Smaller works such as adding additional gullies and buddle holes will also benefit the depth of flooding in Stoke Road although this will only remove an average of 3l/s of flow per gully.

This location has been assessed assuming that some flow can be stored upstream between The Mead and Hilary Cottage (see section 4.6). Initially a flow allowance of 100l/s over the various storm durations has been included as being released from a point 100m downstream of the Mead at location 291925, 69470. This will be adjusted once the capacity of the pipes between Hillary Cottage and The Firs have been surveyed and assessed.

The catchment flows at the village hall were recalculated using the EA data and the additional flows that shed off the green lanes. No other additional land has been identified that joins the catchment. For the storage assessment we have assumed that these flows will be captured using cut off ditches and directed into the storage area by pipe or open channel. The adjusted flows used for the village hall are in the following table:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	0.749
Q2.33 (Mean Annual Flood)	0.849
Q10	1.273
Q25	1.681
Q50	2.076
Q100	2.569

The existing pipe run in Stoke Road is a 450mm pipe with capacity between 340l/s and 684l/s.

The runoff from the area of highway and the additional roofs draining onto the highway has been assessed. A road length of 429m of road (Gabwell Cross to Rose Cottage) at an average width of 5.0m (2145m<sup>2</sup>) has been used together with a net area of 1326m<sup>2</sup> of roof and paving. The following flows have been calculated:

Return Period	Highway area flow 2145m <sup>2</sup> - (l/s)	Highway and property area flow 3338m <sup>2</sup> - (l/s)
Q2 (QMED)	29.1	45.2
Q2.33 (Mean Annual Flood)	33.0	51.3
Q10	49.4	76.8
Q25	65.3	101.5
Q30	69.3	107.7
Q50	80.7	125.3
Q100	99.8	155.1

From this the proportion of flows from highway and property that utilise the culvert can be seen compared to the minimum capacity of 340l/s in the 450mm pipe.

The runoff from the highway and property has 10 opportunities between April Cottage and Rose Cottage to join the flows in the culvert via the existing gullies. The two gullies on the east side of Stoke Road have not been picked up in the CCTV survey as being connected to the watercourse pipe system and these may be connected to the SWW combined sewer. This may be clarified by the SWW/TDC Infiltration study and adjustments to the following flow calculations may be required. Typically a gully is designed to accommodate flow from an area of 200m<sup>2</sup>. Each gully along Stoke Road is expected to deal with flows of 334m<sup>2</sup> plus the flow off the green lane opposite April Cottage.

#### Option 1 – Upstream storage

A preliminary assessment of the valley upstream of the pond has been undertaken using the contour information.

To test the volumes of potential storage required the 50 year flow generated by the highway and property area from the table above has been deducted from the lowest capacity of the 450 pipe section. This leaves a flow of 215l/s which might discharge from the attenuation upstream without overwhelming the pipe system in Stoke Road. The 125l/s is the approximate runoff that SWW would expect their pipe system to be designed to accommodate based on the contributing areas of highway, roof and paving.

Using the hydrograph flows generated earlier a value of 115l/s (215 – 100l/s from The Mead attenuation area) has been deducted from each time interval to represent the flow that can be released to join the flow contribution from Stoke Road and property below the location of the storage area. This leaves a range of values between 0 and 2.454m<sup>3</sup>/s to calculate the runoff volume for.

Using a spreadsheet the potential volumes of runoff in the 25yr, 50yr and 100yr critical storm are calculated as 13,396m<sup>3</sup>, 16,868m<sup>3</sup> and 21,243m<sup>3</sup>.

A SWW sewer runs down through the valley location. SWW have been contacted about potential works over or around the sewer. They have advised that they would not wish to see the cover to the pipe reduced and any increase in cover would need to have the additional load assessed. We have tried to fit around the SWW MH and these constraints but this reduces the potential earthworks opportunities and the potential volumes of storage. Using the height data and contours preliminary sketch options have been developed showing how much land and excavation could be achieved.

The initial design has tested a dam 1m high constructed across the valley at two locations. Scraping a nominal amount off the ground above the sewer and excavating into the hillside to the east. Other configurations are possible but until the topographical survey confirms the profile in more detail this is very approximate as the watercourse is not shown located in the valley bottom according to the contours created from the height data points.

The initial design is between Pools Weir for a distance of 125m north where the ground is relatively flat. The design uses the land between the 48m and 47m contour values and an invert of 47m. The upstream and downstream faces of the dam has been graded at 1 in 3 slopes with the east side of the valley being regraded to 1 in 3 slopes. The footprint area of the dam is 150m<sup>2</sup>. The upstream valley area regraded to 1 in 3 has an area of 2800m<sup>2</sup>. This has provided a storage volume of 2190m<sup>3</sup>, 50% of the Mean Annual Flood volume.

A further test of volume has been carried out further north and to the east of Briar Cottage. The design uses the land between the 44.5m and 43.5m contour values and an invert of 43.5m. The upstream and downstream faces of the dam has been graded at 1 in 3 slopes with the east side of the valley being regraded to 1 in 3 slopes. The footprint area of the dam is 265m<sup>2</sup>. The upstream valley area regraded to 1 in 3 has an area of 2240m<sup>2</sup>. This has provided a storage volume of 1220m<sup>3</sup>, 20% of the Mean Annual Flood volume.

The volumes show that the public sewer is a major constraint and that the earthworks can only provide relatively small volumes of attenuation if the SWW constraints are observed.

These layouts are shown on drawing 421\SV8.

The dam faces and side slopes can be used for grazing at the 1 in 3 design slopes. The existing field has slopes up to in 1 in 6.5 at present.

To progress a more detailed design a topographical survey should be undertaken. Once the detailed survey information including the SWW MH cover and invert levels is available the footprint(s) and volumes can be worked up in more detail to whatever standard of protection is deemed appropriate. Further discussion with SWW will be required once the more detailed survey and design options are available.

The outflow from the storage area could be increased and the volumes of storage calculated could be adjusted downwards as it takes approximately 40 minutes duration in the 100 year storm for the upstream catchment to respond with the flow rate of 115l/s. During this time the bulk of the road and roof areas should have already drained away leaving additional spare capacity within the culvert. This assumes that there is one storm and it passes, if a second intense rainfall event occurs within 30 minutes then this option would mean surcharging of the existing pipe under Stoke Road. An assessment of this risk will be undertaken in the detailed design.

#### Option 2 – Interception ditches in the field east of the village hall

The current flow regime has overland flow discharging from the green lane to Higher Common Farm Barn and land to the east into Stoke Road. The optimum location to install cut off ditches is in the field immediately east of the village hall.

Buddle holes in the green lane hedge adjacent to the gate would be needed to connect the flow from the catchment to the northeast to the cut off ditches.

The detailed design and flow discharge rates of these areas will need to tie into the attenuation designed under Option 1 with any volumes in the cut off ditch contributing to the total volumes of storage required.

All these potential flood alleviation features are included on drawing 421\SV8.

#### Option 3 – Enlarging the existing watercourse pipe or construct an oversized public surface water sewer along Stoke Road

There are two sections of 450mm pipe (Gy5-GY6-GY7) which have significantly less capacity than the other lengths. These should be investigated to determine whether they can be enlarged or twin parallel pipes can be installed to increase capacity. A check on other utility services will be required to see if they are a constraint. The cover to the pipes at this location is only 180/190mm so a larger pipe would need to be constructed with a lower invert level and the 75mm difference lost by decreasing the overall gradient. A 525mm pipe to replace the last three sections of 450mm pipe (66.2m length) would provide at least another 100l/s capacity and allow additional flows from

the upstream storage area to be released. This would reduce the average storage volume by 1675m<sup>3</sup> through the 25yr, 50yr and 100yr storms.

The existing dwellings and paved areas that drain into Stoke Road could be connected to a length of new public surface water sewer. This would be in conjunction with SWW and would draw on the infiltration survey undertaken by Teignbridge. If SWW have identified existing surface water runoff areas that connect to their foul sewer these could be removed and added to the areas identified in this study that contribute to flooding in Stoke Road. This would be connected to the box culvert where the full capacity flow is underutilised.

The contributing flow from the net area of 1326m<sup>2</sup> roofs and paving has been deducted from the calculations included in Option 1. This allows the flow from the attenuation area of Option 1 to be increased by 44l/s to 159l/s. The result of this is that the volumes of attenuation reduce to 12645, 16103, and 20451m<sup>3</sup> in the 25yr, 50yr and 100yr critical storms; an average reduction of 769m<sup>3</sup> of storage.

If a 300mm pipe was laid at a similar gradient to the existing watercourse of 1 in 50 it would have a capacity of 157l/s; i.e. over three times that needed for the roofs and paved areas identified to date in this study. The pipe would start near the school connect to SWW MH6514 outside the Village shop. The downstream box culvert system has adequate capacity to accommodate this additional flow.

The delivery of this pipe would rely on a route being available through other utility services within Stoke Road although there is over 1.3m of fall between the school and the village shop. There is an existing 225mm diameter SWW foul / combined sewer that runs along the preferred route of any new surface water sewer. If this is a constraint a shorter length of pipe could be delivered from MH6514 working upstream if a clash with this or any other services is identified.

#### Option 4 – As option 3 with highway areas

This option would be the same as option 4 but would also include the provision of additional road gullies connected to the additional or enlarged pipe.

Stoke Road varies between crossfall and camber along its length. At present all the gullies are located on the west side of the road except for one opposite the school. Where lengths of the road have camber with the highest point in the centre of the road the additional pipe and gullies would remove flows from the watercourse culvert freeing up potential to release more flow from any upstream storage area.

To determine the suitable areas a detailed topographical survey of Stoke Road will be required that picks up each channel and the centre line level every 10m along the road.

#### Option 5 – Smaller works

Spare capacity has been identified in some lengths of the box culvert surface water system. Additional gullies installed in Stoke Road would remove flows from the highway, roof and paved areas.

#### Summary of options

The following table summarises the above options. The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. Costs will be added at a later date once survey work and further design is completed:

Location & Option	Brief description	No properties benefitting	Budget Costs £k
Option 1	Upstream storage	26 – 30	-
Option 2	Interception ditches & buddle hole(s)	11 – 15	-
Option 3	Ex pipe enlarged or duplicated for property connections	11 – 15	-
Option 4	Ex pipe enlarged or duplicated for property and highway connections	11 – 15	-
Option 5	Small works: Additional gullies	11 – 15	-

#### 4.6 Stoke Road (Lower Gabwell)

The source of flooding considered under this section is from the fields and road south and east of Hilary Cottage. Flows run into Hilary Cottage and the highway. Ponding occurs around Gabwell Tithe Barn. Flows also run from The Knut House and the stables to the east. An existing pipe and gully system along Stoke Road collects some flows. This continues north along the road before heading northeast across the grounds of Gabwell Court and reappearing as an open watercourse adjacent to The Firs.

The catchment areas at this location do not require any adjustment as no additional fields or gates have been identified that divert flows.

An assessment of the gully and roof areas that drain to each length of pipe will need to be completed together with the CCTV and level survey.

The catchment flows at The Mead were recalculated using the EA data. The flows used for The Mead are in the following table:

Return Period	Flow (m <sup>3</sup> /s)
Q2 (QMED)	0.444
Q2.33 (Mean Annual Flood)	0.504
Q10	0.755
Q25	0.998
Q50	1.233
Q100	1.525

There are a few options that can be considered that will reduce the risk of flooding at this location. The main solutions are:

- 1) Intercept the flows south of Hilary Cottage and create a storage area between The Mead and Hilary Cottage. This will reduce the potential volume of storage required between Pools Weir and the village hall as the upper parts of the catchment will be restricted in flow as they pass downstream;
- 2) Enlarge the existing twin 150mm pipes or construct an open watercourse that runs under the field from opposite Sunny Bank down to Hilary Cottage. The downstream system is understood to be a 300mm or 375mm diameter pipe but would need to be investigated by CCTV around Lower Gabwell between Hilary Cottage and The Firs to see what flows could actually be accommodated;

Option 1 – Upstream Storage

A preliminary assessment of the valley has been undertaken using the contour information.

To test the volumes of potential storage required in the 25, 50 and 100 year storms a flow of 100l/s has been allowed to continue downstream towards Hilary Cottage and Pools Weir. This is the approximate capacity of twin 150mm pipes laid at 1 in 100 gradient. The flow can be adjusted once the CCTV survey work has been completed and the storage area at Pools Weir asses in more detail.

Using the hydrograph flows generated earlier a value of 100l/s has been deducted from each time interval. This leaves a range of values between 0 and 1.425m<sup>3</sup>/s to calculate the runoff volume for.

Using a spreadsheet the potential volumes of runoff in the 25yr, 50yr and 100yr critical storm are calculated as 6,763m<sup>3</sup>, 8,639m<sup>3</sup> and 11,003m<sup>3</sup>.

The initial design has tested a dam 2.75m high constructed across the valley. Other configurations are possible such as two shallower areas that cascade down the valley.

The initial design is between The Mead and Hilary Cottage at grid reference 291925, 69470 over a distance of 120m north where the ground is relatively flat. The design uses the land between the 60m and 63m contour values and an invert of 60.25m. The upstream and downstream faces of the dam have been graded at 1 in 3 slopes with the upstream valley sides being regraded to 1in 4 slopes to create the storage area. The footprint area of the dam is 1457m<sup>2</sup>. The upstream valley regraded to 1 in 4 has an area of 4818m<sup>2</sup>. This has provided a storage volume of 11412m<sup>3</sup>, slightly larger than the 1 in 100 year flood volume.

An alternative would be to reduce the size of this single storage area slightly and create a second area immediately southeast of Hilary Cottage. This could be investigated once discussions with land owners commence.

The layout is shown on drawing 421\SV9.

The dam faces and side slopes can be used for grazing at the 1 in 3 and 1 in 4 design slopes. The existing field has slopes up to in 1 in 7 at present.

To progress a more detailed design a topographical survey should be undertaken. Once the detailed survey information is available the footprint(s) and volumes can be worked up in more detail to whatever standard of protection is deemed appropriate.

Option 2 – Enlarge the twin 150mm pipe system

The downstream catchment area north of the storage area including Hilary Cottage and the paved areas are included in the Pools Weir volume calculations. If the existing 300/375mm pipes around Gabwell are found to have greater capacity than the total of the highway and paved areas larger flows could be released from the storage area in Option1 and the twin 150mm pipes enlarged or a new watercourse channel created. This could only be achieved if sufficient storage volumes can be achieved between the village hall and Pools Weir Road or downstream pipes are improved between April Cottage and the village shop.

Summary of options

The following table summarises the above options. The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. Costs will be added at a later date once survey work and further design is completed:

<b>Location &amp; Option</b>	<b>Brief description</b>	<b>No properties benefitting</b>	<b>Budget Costs £k</b>
Option 1	Upstream storage	26 – 30	-
Option 2	Enlarge twin 150m pipe	0 – 5	-

#### 4.7 Summary and Preliminary Cost Benefit Ratio Assessment

Each flood alleviation option has been considered against the potential cost and construction complexity involved. The different schemes each offer some benefit to the properties that have flooded in the past.

The frequency of flooding and number of properties impacted has been compared against the alleviation works and ranked in terms of the most benefit available.

The number of properties benefitting are those that the flood flows pass on the way to rejoin the watercourse downstream of Victoria Farm. To date 36 properties have been identified that have either experienced internal flooding or used temporary preventative measures to alleviate the flood water. An additional 4 properties have yet to be contacted to confirm whether they have / would have experienced flooding.

The table below details the top 5 larger schemes that should be investigated in more detail and costed to determine the cost benefit ratio available. These are all subject to funding being available and there is no guarantee all of these will be delivered:

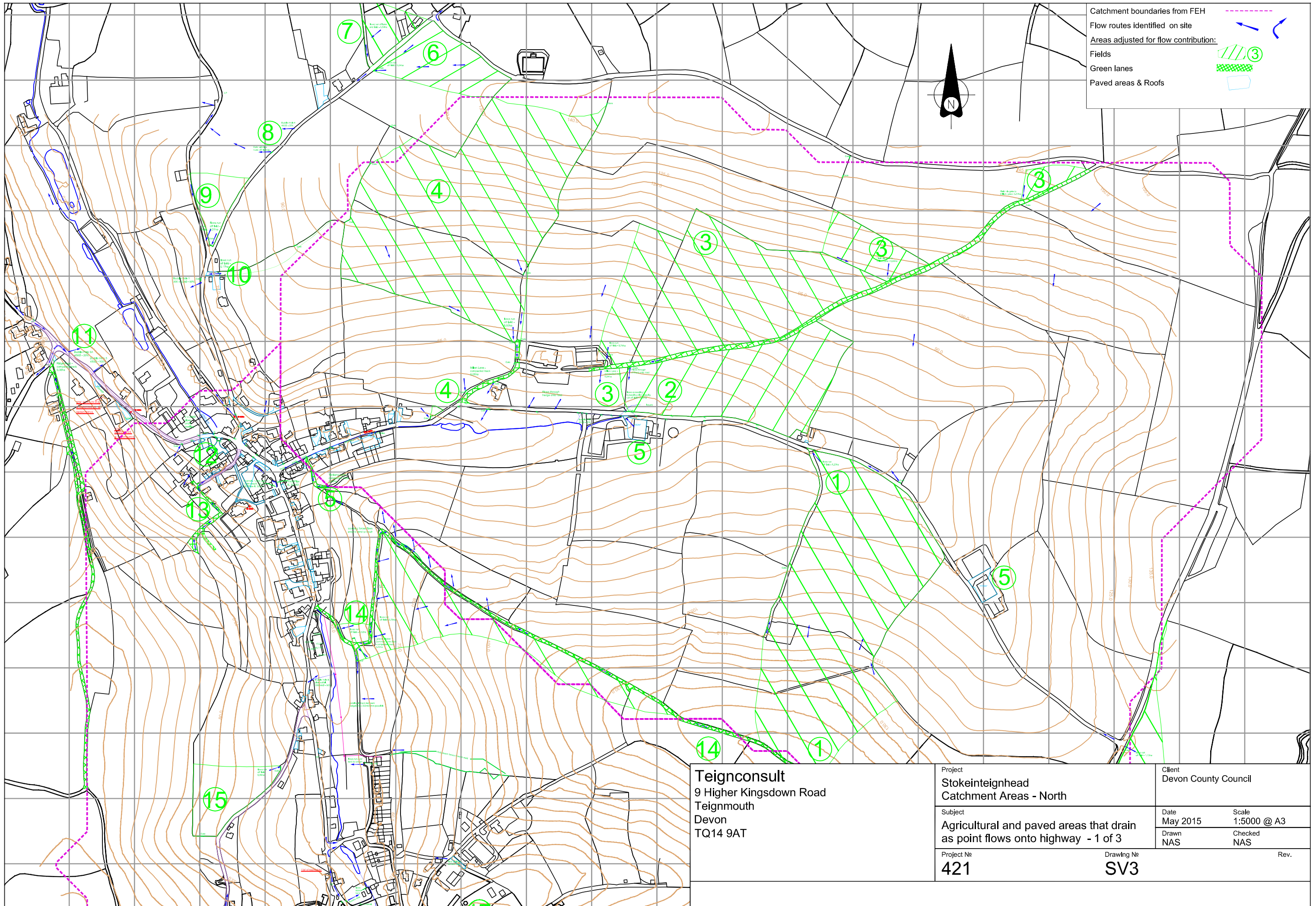
<b>Location &amp; Option</b>	<b>Brief description</b>	<b>No properties benefitting</b>
Deane Rd Options 1 & 2	Upstream storage and interception ditches around Deane House	21 - 25
Stoke Rd – Deane Rd Options 1 & 2	Cut off ditches and silt traps	26 - 30
Ivy Tree Hill Options 3 & 4	New connection between highway drainage and box culvert and SWW sewer levels	11 - 15
Forches Hill Option 1	New pipe to Rock Cottage & connect new and existing gullies, roof and paved areas into the system	11 – 15
Church Lane Option 5	New pipe and gullies connected to box culvert	11 - 15

Some of these schemes may rise or drop in the ranking once the utility records are considered as it is very easy to spend £20,000 diverting cables and other equipment.

Other minor works such as additional gullies and buddle holes can also be undertaken that will reduce the overall flood risk.

## **DRAWINGS**

Drawing SV3	Catchment Areas – North
Drawing SV4	Catchment Areas – Centre
Drawing SV5	Catchment Areas – South
Drawing SV6	Deane Road / Millen Lane Flood Alleviation Options
Drawing SV7	Forches Hill / Ivy Tree Hill / Stoke Cross Flood Alleviation Options
Drawing SV8	Village Hall to Pools Weir Flood Alleviation Options
Drawing SV9	The Mead to Hilary Cottage Flood Alleviation Options



Catchment boundaries from FEH

Flow routes identified on site

Areas adjusted for flow contribution:

- Fields
- Green lanes
- Paved areas & Roofs

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Project  
**Stokeinteignhead  
 Catchment Areas - North**

Subject  
**Agricultural and paved areas that drain  
 as point flows onto highway - 1 of 3**

Project No  
**421**

Client  
 Devon County Council

Date  
 May 2015

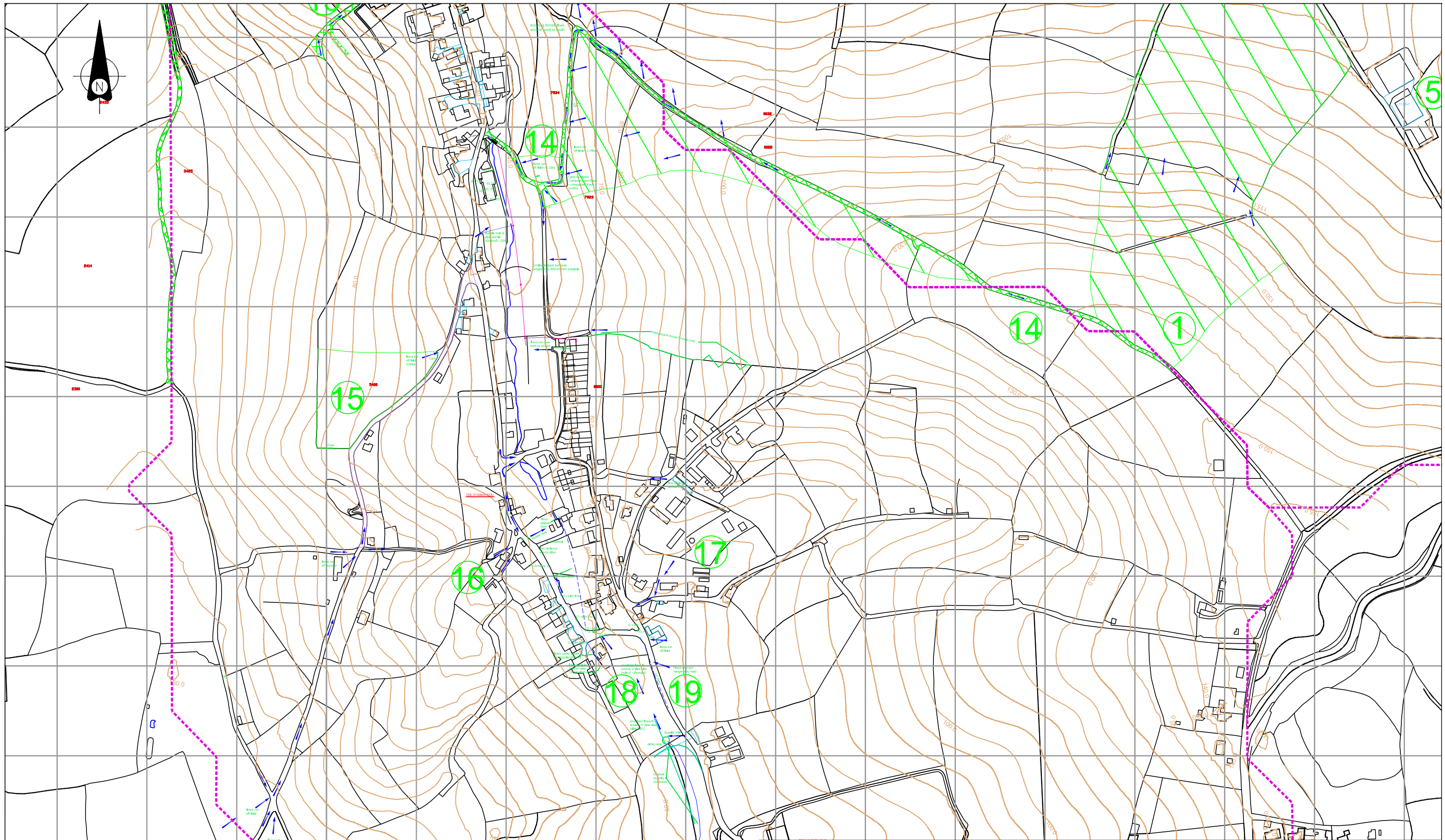
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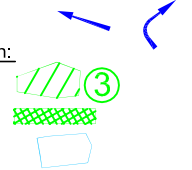
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Drawing No  
**SV3**

Rev.



Catchment boundaries from FEH  
 Flow routes identified on site  
 Areas adjusted for flow contribution:  
 Fields  
 Green lanes  
 Paved areas & Roofs

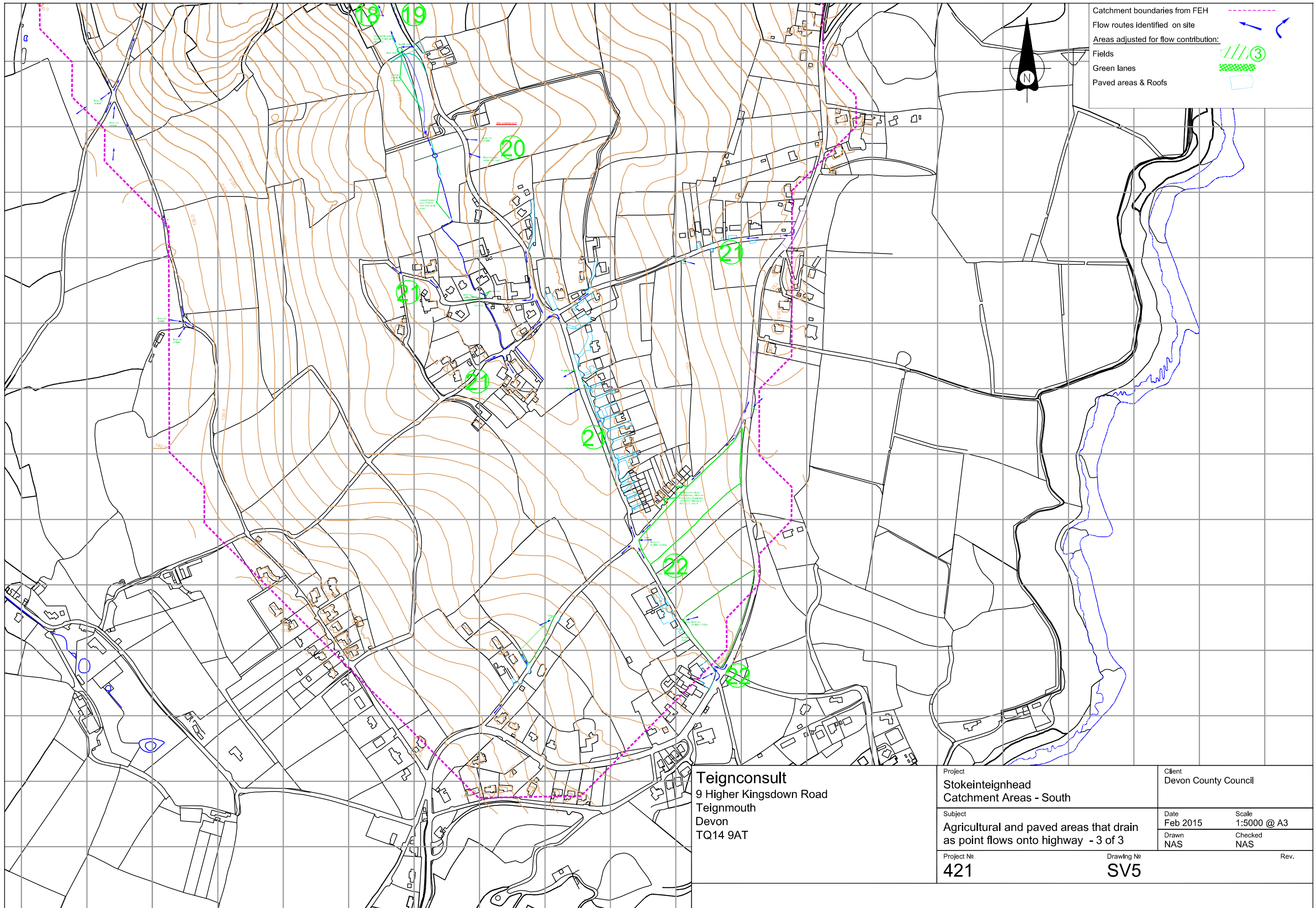


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Project  
**Stokeinteignhead  
 Catchment Areas - Centre**  
 Subject  
**Agricultural and paved areas that drain  
 as point flows onto highway - 2 of 3**

Client  
 Devon County Council  
 Date  
 Feb 2015  
 Scale  
 1:5000 @ A3  
 Drawn  
 NAS  
 Checked  
 NAS

Project No  
**421**  
 Drawing No  
**SV4**  
 Rev.



Catchment boundaries from FEH - - -

Flow routes identified on site →

Areas adjusted for flow contribution:

Fields ▨ ③

Green lanes ▨

Paved areas & Roofs □



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 Devon  
 TQ14 9AT

Project  
**Stokeinteignhead**  
 Catchment Areas - South

Subject  
 Agricultural and paved areas that drain  
 as point flows onto highway - 3 of 3

Client  
 Devon County Council

Date  
 Feb 2015

Scale  
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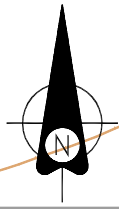
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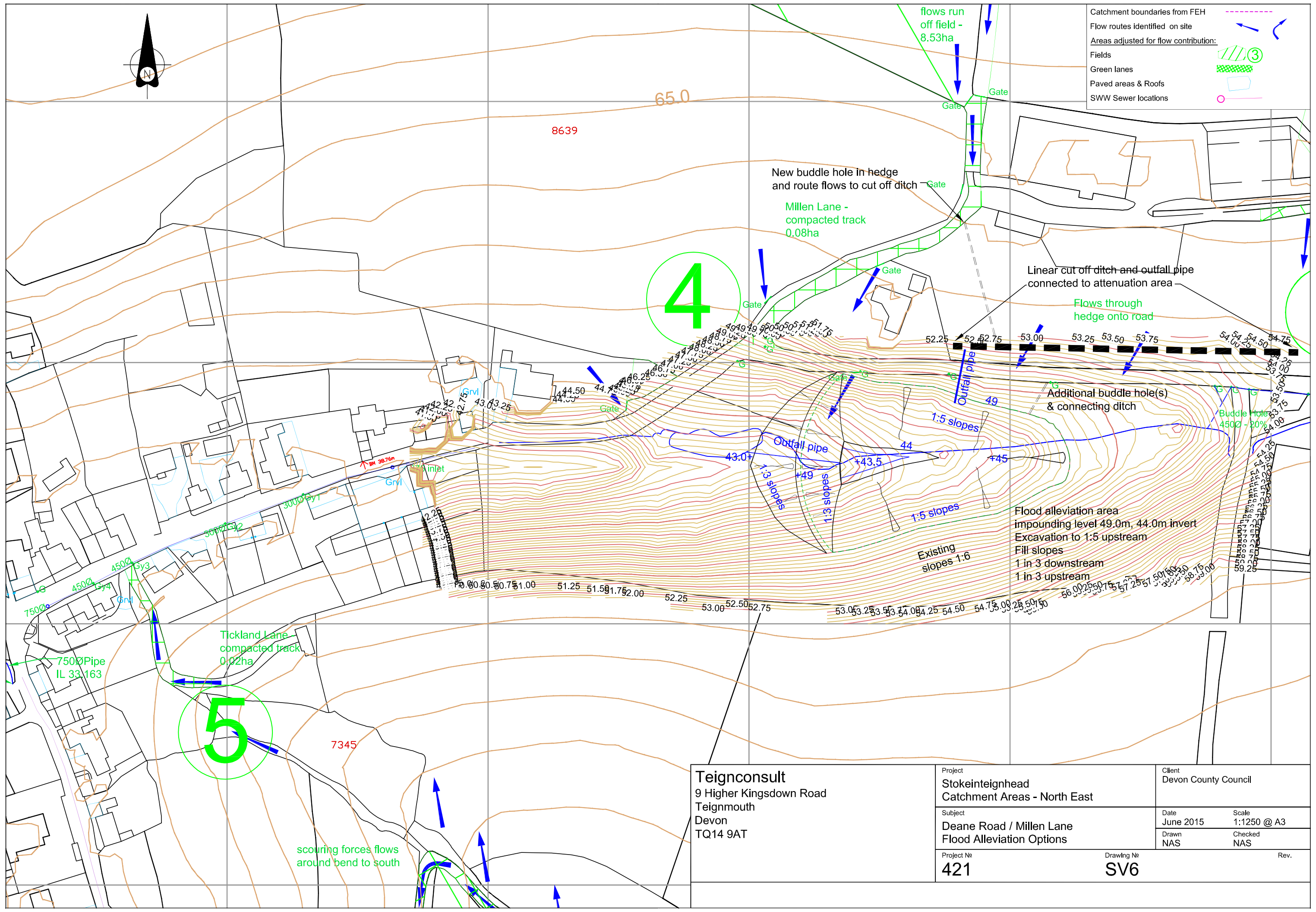
Project No  
**421**

Drawing No  
**SV5**

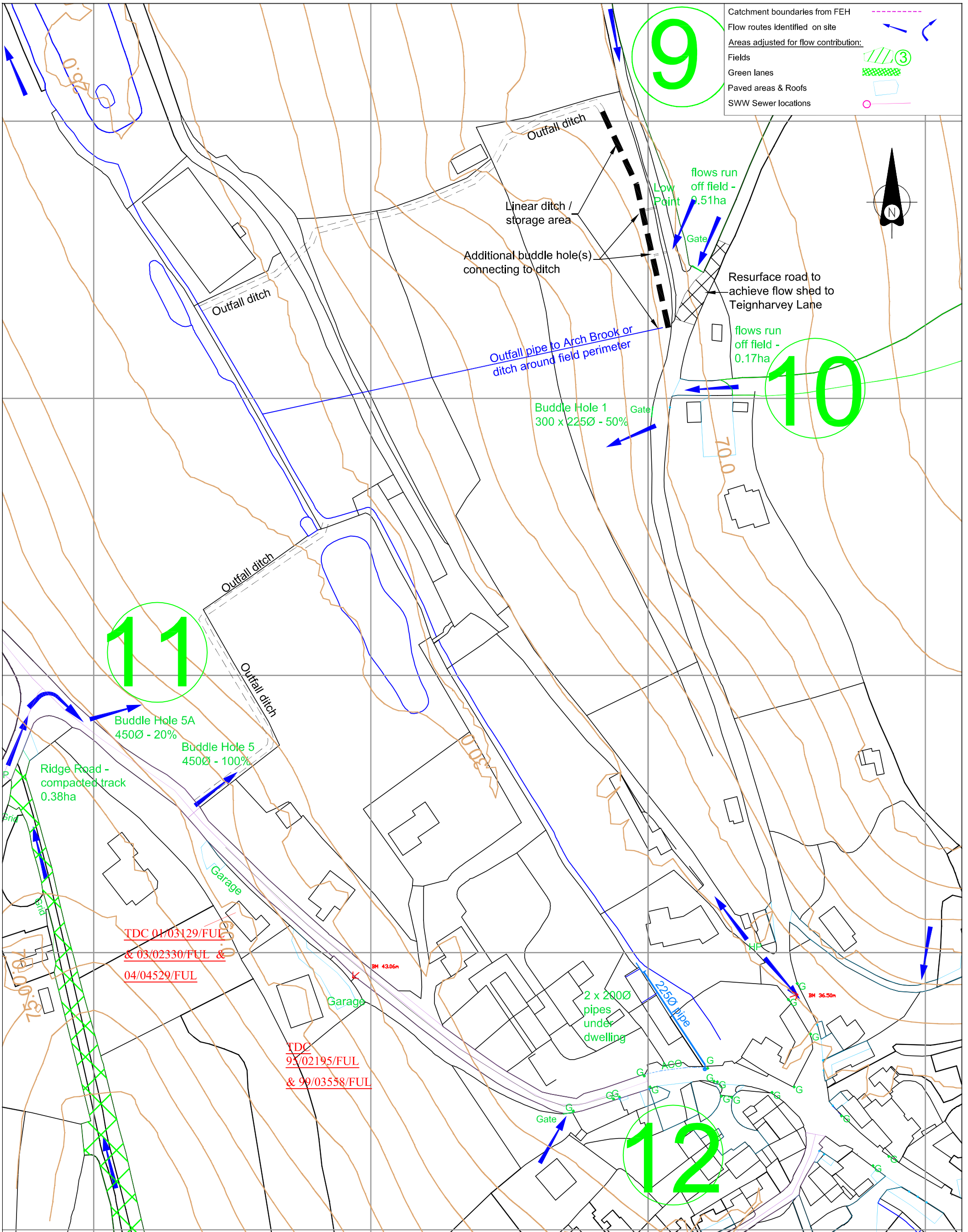
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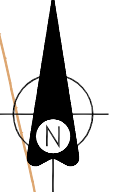
Catchment boundaries from FEH	
Flow routes identified on site	
Areas adjusted for flow contribution:	
Fields	
Green lanes	
Paved areas & Roofs	
SWW Sewer locations	



<b>Teignconsult</b> 9 Higher Kingsdown Road Teignmouth Devon TQ14 9AT	Project <b>Stokeinteignhead          Catchment Areas - North East</b>	Client Devon County Council	
	Subject <b>Deane Road / Millen Lane          Flood Alleviation Options</b>	Date June 2015	Scale 1:1250 @ A3
	Project No <b>421</b>	Drawing No <b>SV6</b>	Rev. 



- Catchment boundaries from FEH ---
- Flow routes identified on site →
- Areas adjusted for flow contribution:
- Fields ▨ ③
  - Green lanes ▨
  - Paved areas & Roofs ▭
  - SWW Sewer locations ○



**Teignconsult**  
 9 Higher Kingsdown Road  
 Teignmouth  
 Devon  
 TQ14 9AT

Project  
**Stokeinteignhead  
 Catchment Areas - North**

Subject  
**Forches Hill / Ivy Tree Hill / Stoke Cross  
 Flood Alleviation Options**

Client  
 Devon County Council

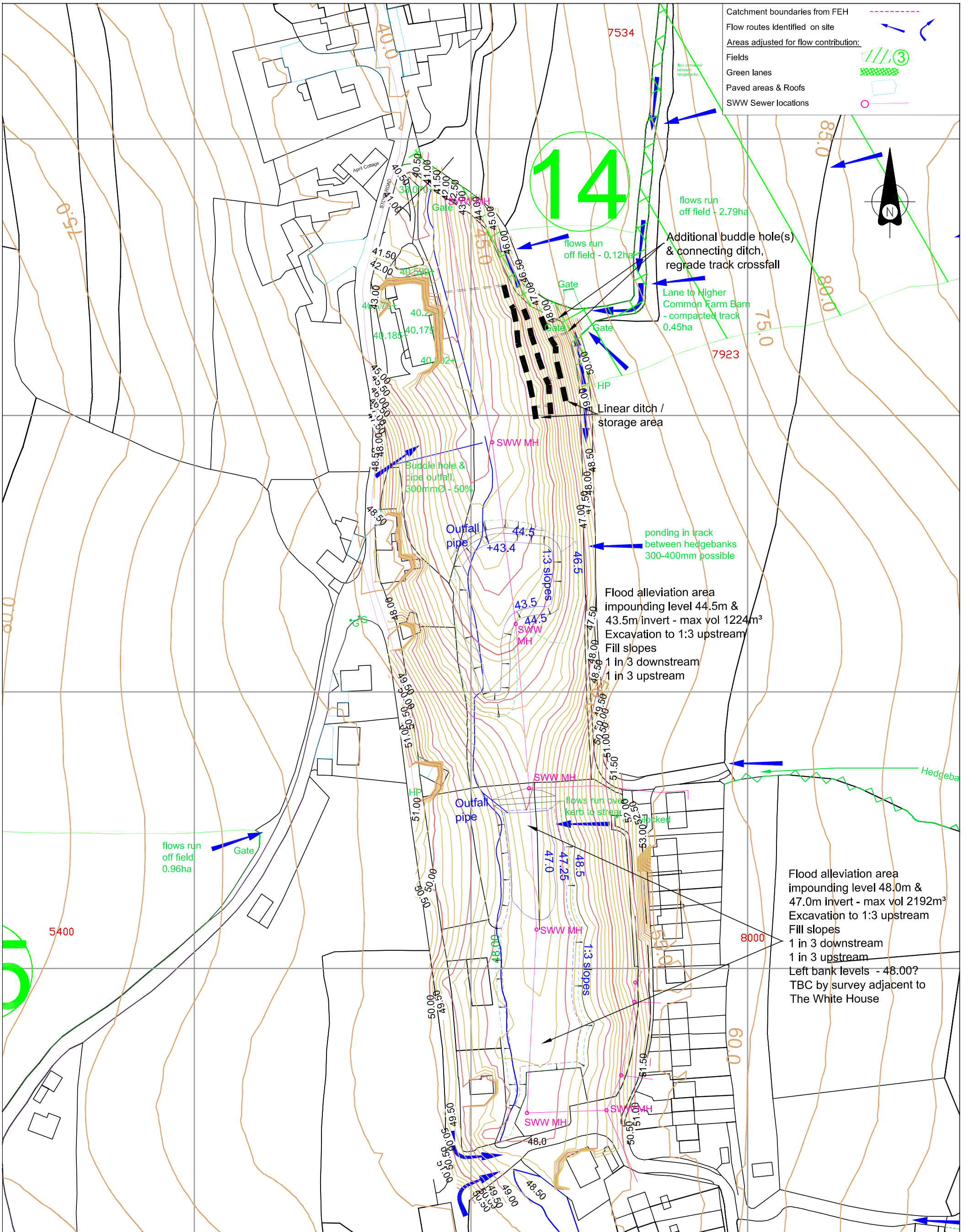
Date  
 June 2015

Scale  
 1:1250 @ A3

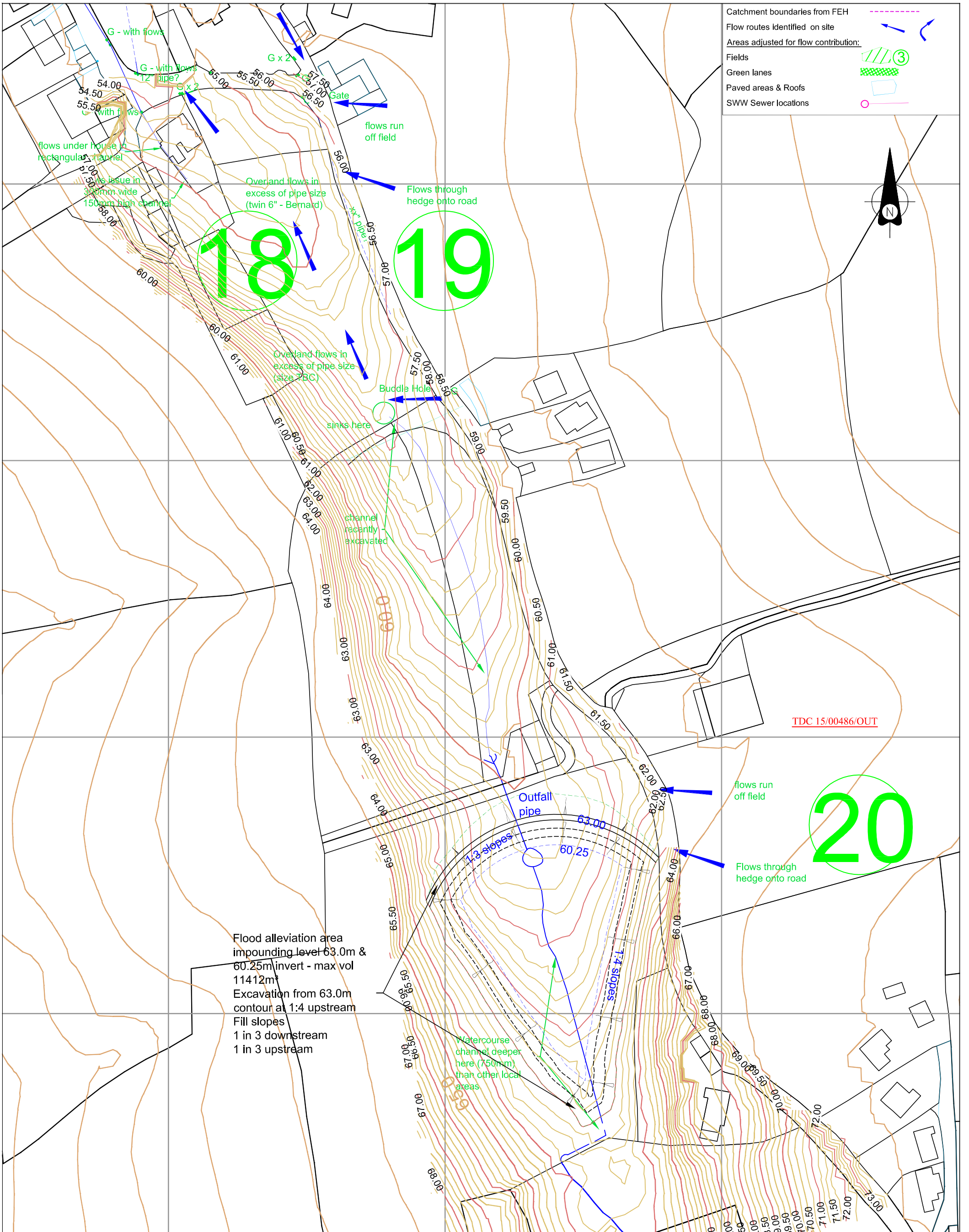
Drawn  
 NAS

Checked  
 NAS

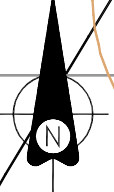
Project No **421** Drawing No **SV7** Rev.



<b>Teignconsult</b> 9 Higher Kingsdown Road Teignmouth Devon TQ14 9AT	Project <b>Stokeinteignhead          Catchment Areas - Centre</b>	Client Devon County Council	
	Subject <b>Village Hall - Pools Weir          Flood Alleviation Options</b>	Date June 2015	Scale 1:1250 @ A3
	Project No <b>421</b>	Drawing No <b>SV8</b>	Drawn NAS
		Rev.	



Catchment boundaries from FEH	
Flow routes identified on site	
Areas adjusted for flow contribution:	
Fields	
Green lanes	
Paved areas & Roofs	
SWW Sewer locations	



18

19

20

Flood alleviation area  
 impounding level 63.0m &  
 60.25m invert - max vol  
 11412m<sup>3</sup>  
 Excavation from 63.0m  
 contour at 1:4 upstream  
 Fill slopes  
 1 in 3 downstream  
 1 in 3 upstream

TDC 15/00486/OUT

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 9 Higher Kingsdown Road  
 Teignmouth  
 Devon  
 TQ14 9AT

Project  
**Stokeinteignhead  
 Catchment Areas - South**

Subject  
**The Mead - Hilary Cottage  
 Flood Alleviation Options**

Client  
 Devon County Council

Date  
 June 2015

Scale  
 1:1250 @ A3

Drawn  
 NAS

Checked  
 NAS

Project No  
**421**

Drawing No  
**SV9**

Rev.

## **APPENDIX A**

### **EA Maps and SWW Sewer Records**

1. EA Flood Map for Surface Water
2. SWW Public sewer records

## Risk of Flooding from Surface Water

Surface water flooding happens when rainwater does not drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead.

The shading on the map shows the risk of flooding from surface water in this particular area.

Click on the map for a more detailed explanation.

**Map of X: 292,052; Y: 69,647** at scale 1:15,000

[Data search](#)

**Map legend**

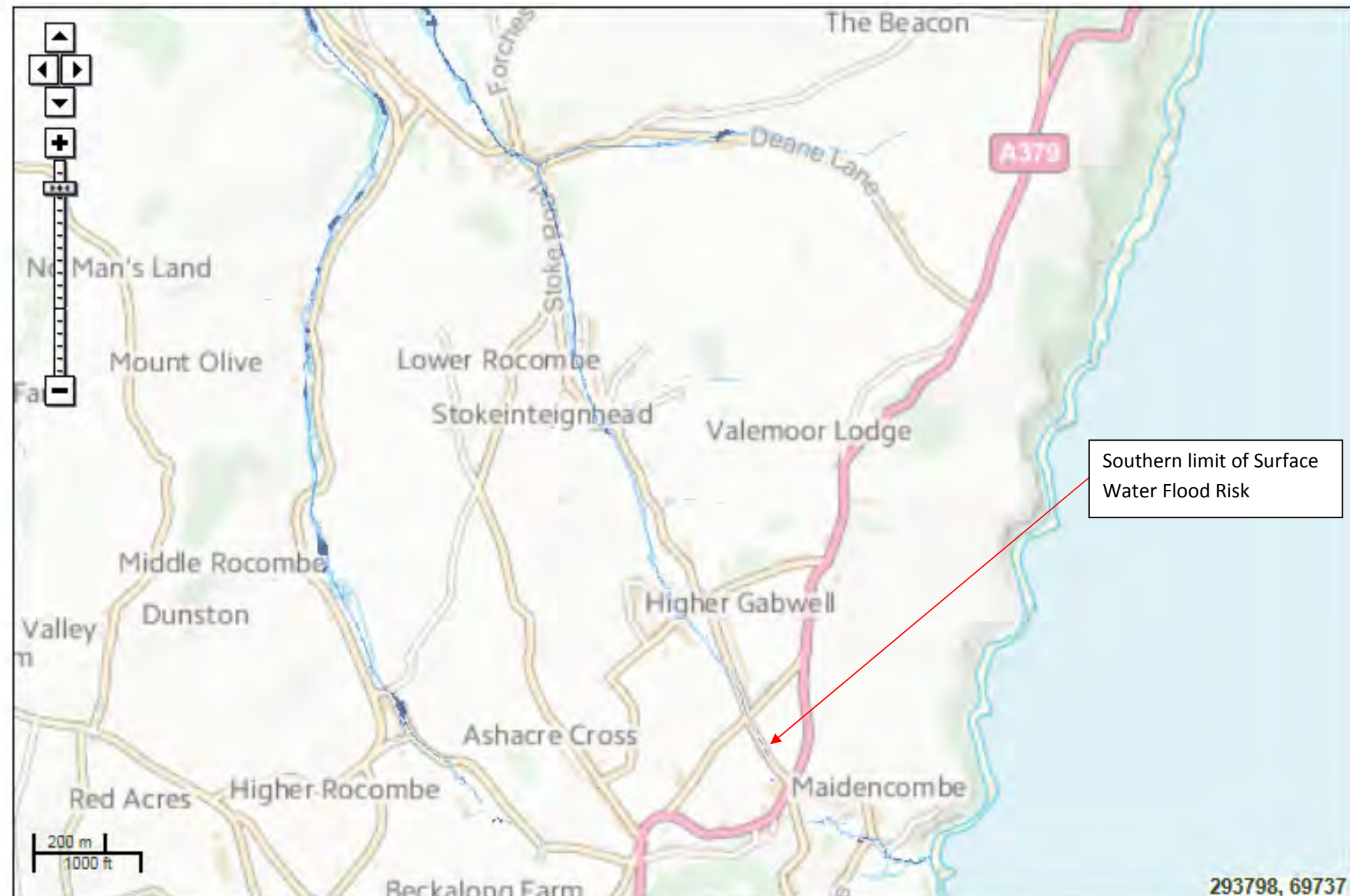
Risk of Flooding from Surface Water

High

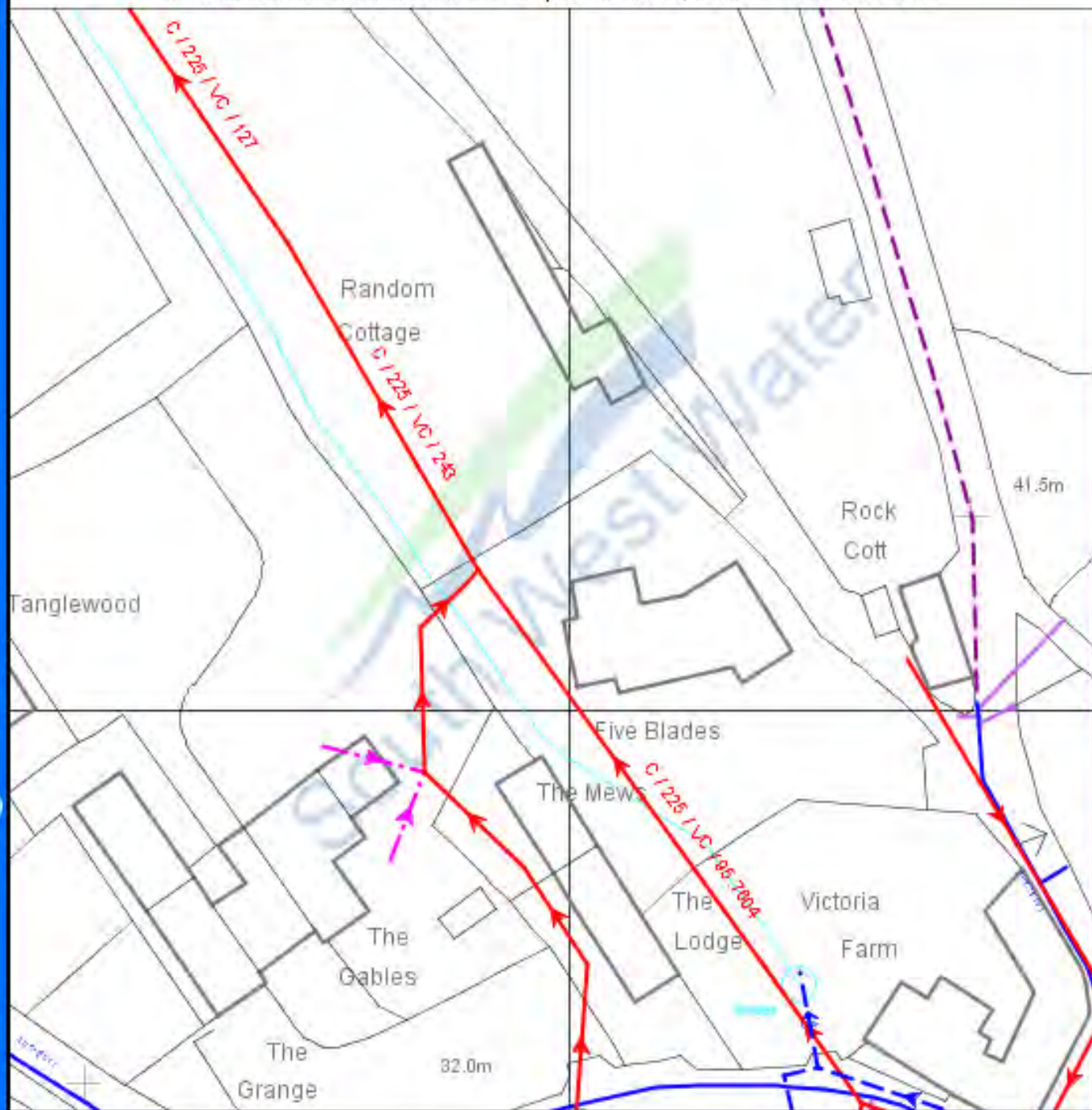
Medium

Low

Very Low







Reproduced from the Ordnance Survey map by South West Water Ltd. by permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office. © Crown copyright South West Water Ltd. Licence number: 100018191

## **APPENDIX B**

### **Catchment Locations and Flows**

1. Design flows for Deane House, Village Hall, The Mead and other locations
2. Hydrograph comparison from hydrology calculation methods

## Pro rata flows based on EA design figures

## Selected catchment locations

	<u>Potential Valley storage locations</u>			<u>Downstream urban reaches</u>			<u>Culvert inlets</u>		Totals (B - L)
	Deane House	Village Hall	The Mead	Deane Rd	Teign Court	Five Blades	Deane Rd inlet	Stoke Rd inlet	
Area (km <sup>2</sup> )	1.054	0.962	0.642	0.191	0.095	0.091	1.190	1.630	3.035
Area (ha)	105.4	96.2	64.2	19.1	9.5	9.1	119	163	303.5
SPR (FEH)	11.75	11.74	11.73						
SAAR	906	927	927						
DPSBAR	161.8	150.5	121.4						
Flows	Pro rata by location for catchment area only								
2	0.730	0.666	0.444	0.132	0.066	0.063	0.824	1.128	2.101
2.33	0.828	0.755	0.504	0.150	0.075	0.071	0.934	1.280	2.383
10	1.240	1.132	0.755	0.225	0.112	0.107	1.400	1.917	3.570
25	1.638	1.495	0.998	0.297	0.148	0.141	1.850	2.534	4.718
50	2.024	1.847	1.233	0.367	0.182	0.175	2.285	3.129	5.827
100	2.503	2.285	1.525	0.454	0.226	0.216	2.826	3.871	7.208

**Deane House**

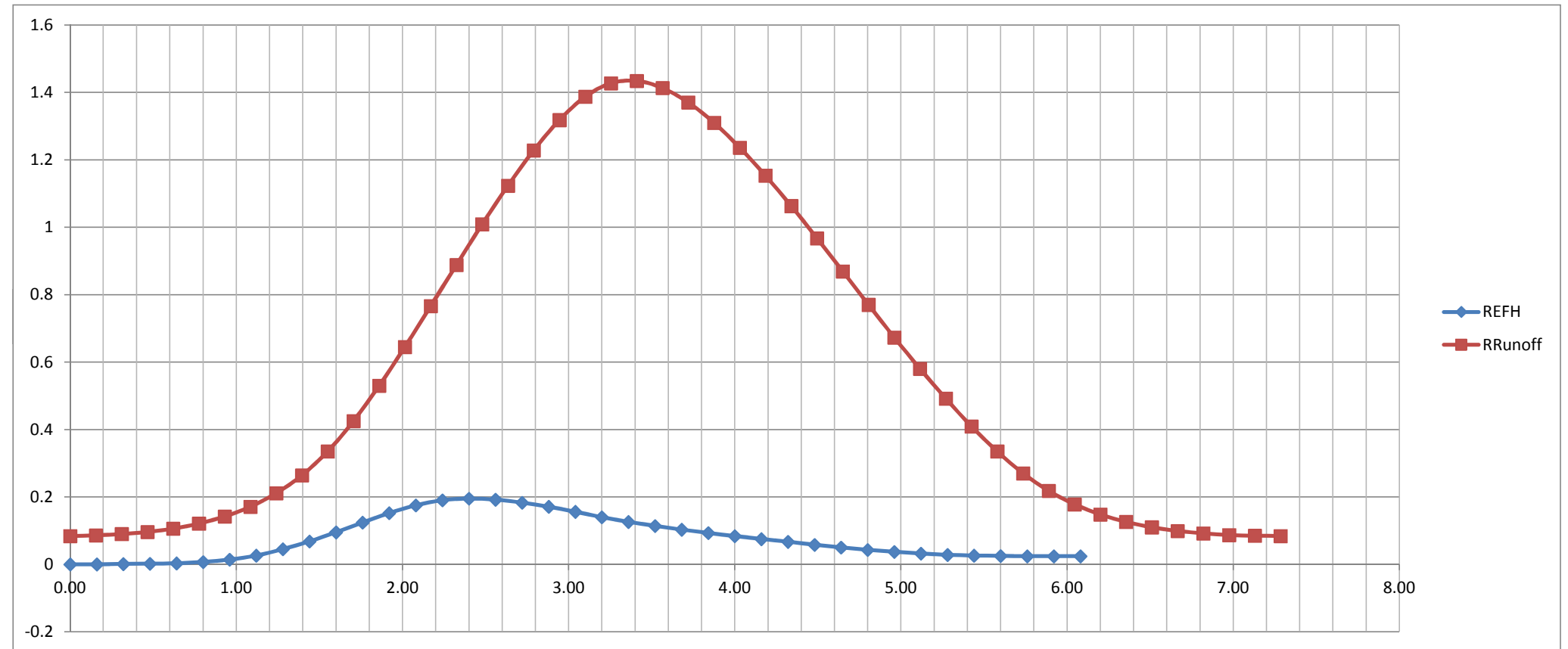
Adjusted flows following catchment assessment: 8.126 % for e/o area.

Amend URBEXT to: 0.0114

Amend catchment area to: 1.14 km<sup>2</sup>

Flows	Base	Area	Track	Adjusted total	
2	0.730	0.059	0.036	0.825	1.131146
2.33	0.828	0.067	0.041	0.936	1.131238
10	1.240	0.101	0.062	1.403	1.131307
25	1.638	0.133	0.082	1.853	1.131249
50	2.024	0.164	0.101	2.289	1.131138
100	2.503	0.203	0.125	2.832	1.131164

REFH Time	Flow	RR Time	Flow
0	0	0	0.084
0.16	0	0.155	0.086
0.32	0.001	0.31	0.09
0.48	0.002	0.465	0.096
0.64	0.003	0.62	0.106
0.8	0.007	0.775	0.121
0.96	0.014	0.93	0.142
1.12	0.026	1.085	0.171
1.28	0.045	1.24	0.211
1.44	0.068	1.395	0.264
1.6	0.095	1.55	0.335
1.76	0.124	1.705	0.425
1.92	0.152	1.86	0.53
2.08	0.175	2.015	0.645
2.24	0.19	2.17	0.766
2.4	0.195	2.325	0.888
2.56	0.192	2.48	1.009
2.72	0.183	2.635	1.123
2.88	0.171	2.79	1.228
3.04	0.156	2.945	1.318
3.2	0.14	3.1	1.387
3.36	0.126	3.255	1.427
3.52	0.114	3.41	1.434
3.68	0.103	3.565	1.413
3.84	0.093	3.72	1.37
4	0.084	3.875	1.31
4.16	0.075	4.03	1.236
4.32	0.067	4.185	1.153
4.48	0.058	4.34	1.063
4.64	0.05	4.495	0.967
4.8	0.043	4.65	0.869
4.96	0.037	4.805	0.77
5.12	0.032	4.96	0.673
5.28	0.028	5.115	0.58
5.44	0.026	5.27	0.492
5.6	0.025	5.425	0.409
5.76	0.024	5.58	0.335
5.92	0.024	5.735	0.27
6.08	0.024	5.89	0.218
		6.045	0.178
		6.2	0.148
		6.355	0.126
		6.51	0.11
		6.665	0.099
		6.82	0.092
		6.975	0.087
		7.13	0.085
		7.285	0.084



## **APPENDIX C**

### **Schedule of Properties Draining onto Highway**

1. List of properties with Roof, paving or gravel areas draining onto highway

## Existing property and paved areas that shed to highway

Road	Property	Area (m2)	Roof (R), Paving (P) or Gravel (G)	
Ivy Tree Hill	Fir Tree Cottage	46	P	
	Golden Dawn	180	R, P	
	Lilac Cottage	23	R, P	
	Holly Cottage	178	R, P	427
Church Lane	Na Mara/Lantern Cottage	46	R	
	Georgian Cottage	38	R	
	Parabel Cottage	38	P	
	St Andrews Church path north	151	P	
Forches Hill	Rose Cottage	17	R, P	290
	Hillaway	354	R, P	
	Hillside/Highview	262	P	
	Rock Cottage	17	P	
	Ashbrook Cottage	59	R, P	
Stoke Cross	Roof Tops	65	R, P	757
	Carlton Court	268	P	
	Daylesford	22	P	
	The Old Forge	13	P	
	Post Office	24	P	
Deane Road	Church House Inn	540	R, P	867
	The Brook	122	P	
	Orchard House	132	R, G	
	Home Farm Court	470	G	
	Home Farm	67	R	
	Langham	107	P	
	Luccombe/Woodruff	82	R, P	
	The Dip	113	P	
	The Stables	53	P	
	Paynes Court Farm	147	P	
	Blossom Hill Cottage	45	P	
	Braeburn Cottage	54	G	
	Honeysuckle Cottage	63	R, P	1455
	Stoke Road	Rose Cottage	33	R
Congdons Farm		26	R	
St Andrews Church path east		100	P	
Jasmine Cottage		26	P	
Coggins		25	P	
The Rectory		123	P	
School Cottages		33	R	
Honeydown		100	P	
Teign Court (9)		54	R	
Teign Court Entrance		20	P	
Teign Court (7, 8, Parking)		81	R, P	
The Orchard		288	P	
The Chasers Arms		214	P	1123
Gabwell Cross		Amberley	67	P
	Coscombe	61	P	
	Briar Cottage	9	P	
	Roslyn	39	R	
	Roslyn garage opposite Coscombe	27	P	203
Lower Gabwell	Codnor Cottages (1)	71	P	
	Codnor Cottages (2)	17	P	
	Lynton House	30	R, P	
	Mondali	80	R, P	
	Gabwell Barn	208	R, P	
	Stables	185	R	
	Hollifields	127	P	
Gabwell Hill	Kindle Cottage	24	R, P	742
	opposite Ashnichol	35	R	
	Swincliffe	51	P	
	Braeside	13	P	
	Cartref	7	P	
	opposite Cartref	24	R	


## Existing property and paved areas that shed to highway

	Pleasant View	66	P	
	Haffod Farm	163	P	
	Nyumbani	106	P	
	Rosemary Cottage	26	P	
	Old Seaway House	71	R, P	562
Longpark Hill	Ryelands	44	P	
	Homeland	7	P	
	Chantry Lodge	14	P	
	Blue Ridge	66	P	
	Merrimead	7	P	138
Stoke Road	Sunny Bank	68	P	
	Lyndhurst/Ryedene/Westholm	384	P	
	Danehurst	217	P	
	Nutcombe House	306	G	
	Gabwell Lodge	367	P	
	Appleshaw	147	P	
	East Park	67	P	
	Stretton	109	P	
	Oaklea/East Park/Stretton	186	G	
	The Wish	225	P	
	Uplands	116	P	
	Fairholme	180	P	
	Leacroft	89	P	
	Green Willow	105	P	
	Kookaburra	178	P	
	Access to The Wish / Uplands / Fairholme / Leacroft / Green Willow /Kookaburra	515	G	
	1	104	P	
	2	59	P	
	3	62	P	
	4	72	P	
	5	40	P	
	6	47	P	
	7	29	P	
	Seaway	226	P	
	Greenbank	386	P	
	Crossways	657	P	4941
Total all areas		11505		11505

## **APPENDIX D**

### **WinDes Pipe & Culvert Data and Output**

1. System 1 Deane Road to Stoke Rd
2. System 1 Stoke Road & Deane Rd to outfall at Victoria Farm

TeignConsult		Page 1
9 Higher Kingsdown Road	Deane Rd	
Teignmouth	culvert system with outfal...	
Devon TQ14 9AT	Stoke Rd box culvert	
Date Mar 15	Designed by NAS	
File Deane Rd varying size...	Checked by	
XP Solutions	Network 2013.1.1	

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	HYD SECT	DIA (mm)
1.000	7.700	0.614	12.5	0.000	4.00	0.0	0.600	o	375
2.000	36.700	0.737	49.8	0.000	4.00	0.0	0.600	o	375
3.000	31.200	1.085	28.8	0.000	4.00	0.0	0.600	o	300
3.001	38.500	1.711	22.5	0.000	0.00	0.0	0.600	o	300
3.002	17.000	0.657	25.9	0.000	0.00	0.0	0.600	o	450
3.003	22.900	0.640	35.8	0.000	0.00	0.0	0.600	o	450
3.004	22.500	0.330	68.2	0.000	0.00	0.0	0.600	o	750

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	4.02	38.094	0.000	0.0	0.0	0.0	5.14	567.7	0.0
2.000	50.00	4.24	37.480	0.000	0.0	0.0	0.0	2.57	284.2	0.0
3.000	50.00	4.18	36.743	0.000	0.0	0.0	0.0	2.94	208.0	0.0
3.001	50.00	4.37	35.658	0.000	0.0	0.0	0.0	3.33	235.3	0.0
3.002	50.00	4.44	33.947	0.000	0.0	0.0	0.0	4.01	637.7	0.0
3.003	50.00	4.55	33.290	0.000	0.0	0.0	0.0	3.41	541.9	0.0
3.004	50.00	4.66	32.650	0.000	0.0	0.0	0.0	3.39	1498.6	0.0

9 Higher Kingsdown Road

Deane Rd

Teignmouth

culvert system with outfal...

Devon TQ14 9AT

Stoke Rd box culvert

Date Mar 15

Designed by NAS

File Deane Rd varying size...

Checked by

XP Solutions

Network 2013.1.1




PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	375	Deane Rd inlet	38.634	38.094	0.165	Open Manhole	1350
2.000	o	375	MH1	38.430	37.480	0.575	Open Manhole	1350
3.000	o	300	Deane GY1	37.223	36.743	0.180	Open Manhole	1050
3.001	o	300	Deane GY2	36.108	35.658	0.150	Open Manhole	1050
3.002	o	450	Deane GY3	34.827	33.947	0.430	Open Manhole	1350
3.003	o	450	Deane Gy4	34.190	33.290	0.450	Open Manhole	1350
3.004	o	750	MH6511	33.840	32.650	0.440	Open Manhole	1800

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	7.700	12.5	MH6514	32.260	37.480	-5.595	Open Manhole	0
2.000	36.700	49.8	MH6514	32.260	36.743	-4.858	Open Manhole	0
3.000	31.200	28.8	Deane GY2	36.108	35.658	0.150	Open Manhole	1050
3.001	38.500	22.5	Deane GY3	34.827	33.947	0.580	Open Manhole	1350
3.002	17.000	25.9	Deane Gy4	34.190	33.290	0.450	Open Manhole	1350
3.003	22.900	35.8	MH6511	33.840	32.650	0.740	Open Manhole	1800
3.004	22.500	68.2	MH6514	32.260	32.320	-0.810	Open Manhole	0

TeignConsult		Page 1
9 Higher Kingsdown Road	Stoke Road & Deane Rd	
Teignmouth		
Devon TQ14 9AT	outfall at Victoria Farm	
Date Mar 15	Designed by NAS	
File Stoke Rd & Deane Rd t...	Checked by	
XP Solutions	Network 2013.1.1	

STORM SEWER DESIGN by the Modified Rational Method

Network Design Table for Storm

PN	Length (m)	Fall (m)	Slope (1:X)	I.Area (ha)	T.E. (mins)	Base Flow (l/s)	k (mm)	n	HYD SECT	DIA (mm)
1.000	19.340	0.860	22.5	0.000	4.00	0.0	0.600		o	450
1.001	12.800	0.370	34.6	0.000	0.00	0.0	0.600		o	450
1.002	27.100	0.750	36.1	0.000	0.00	0.0	0.600		o	450
1.003	76.400	1.430	53.4	0.000	0.00	0.0	0.600		o	450
1.004	45.200	0.500	90.4	0.000	0.00	0.0	0.600		o	450
1.005	19.100	0.270	70.7	0.000	0.00	0.0	0.600		o	450
1.006	1.870	0.050	37.4	0.000	0.00	0.0	0.600		o	450
1.007	8.500	0.080	106.3	0.000	0.00	0.0		0.020	_	-7
1.008	1.560	0.260	6.0	0.000	0.00	0.0	0.600		o	750
1.009	6.140	0.070	87.7	0.000	0.00	0.0	0.600		o	750
1.010	11.890	0.510	23.3	0.000	0.00	0.0	0.600		o	750
2.000	7.700	0.614	12.5	0.000	4.00	0.0	0.600		o	375
2.001	36.700	0.737	49.8	0.000	0.00	0.0	0.600		o	375
2.002	31.200	1.085	28.8	0.000	0.00	0.0	0.600		o	375
2.003	38.500	1.711	22.5	0.000	0.00	0.0	0.600		o	375
2.004	17.000	0.657	25.9	0.000	0.00	0.0	0.600		o	450
2.005	22.900	0.640	35.8	0.000	0.00	0.0	0.600		o	450
2.006	22.500	0.330	68.2	0.000	0.00	0.0	0.600		o	750
1.011	37.930	0.560	67.7	0.000	0.00	0.0	0.600		[ ]	-5
1.012	18.280	0.140	130.6	0.000	0.00	0.0	0.600		[ ]	-6
1.013	16.910	0.240	70.5	0.000	0.00	0.0	0.600		[ ]	-6
1.014	22.810	0.220	103.7	0.000	0.00	0.0	0.600		[ ]	-6
1.015	8.770	0.030	292.3	0.000	0.00	0.0	0.600		[ ]	-6

Network Results Table

PN	Rain (mm/hr)	T.C. (mins)	US/IL (m)	Σ I.Area (ha)	Σ Base Flow (l/s)	Foul (l/s)	Add Flow (l/s)	Vel (m/s)	Cap (l/s)	Flow (l/s)
1.000	50.00	4.07	37.470	0.000	0.0	0.0	0.0	4.30	684.2	0.0
1.001	50.00	4.14	36.610	0.000	0.0	0.0	0.0	3.47	551.2	0.0
1.002	50.00	4.27	36.240	0.000	0.0	0.0	0.0	3.39	539.3	0.0
1.003	50.00	4.73	35.490	0.000	0.0	0.0	0.0	2.79	443.1	0.0
1.004	50.00	5.08	34.060	0.000	0.0	0.0	0.0	2.14	340.2	0.0
1.005	50.00	5.21	33.560	0.000	0.0	0.0	0.0	2.42	384.8	0.0
1.006	50.00	5.22	33.290	0.000	0.0	0.0	0.0	3.33	530.0	0.0
1.007	50.00	5.27	33.240	0.000	0.0	0.0	0.0	2.59	4262.9	0.0
1.008	50.00	5.28	33.160	0.000	0.0	0.0	0.0	11.47	5065.6	0.0
1.009	50.00	5.31	32.900	0.000	0.0	0.0	0.0	2.99	1320.6	0.0
1.010	50.00	5.34	32.830	0.000	0.0	0.0	0.0	5.81	2566.9	0.0
2.000	50.00	4.02	38.094	0.000	0.0	0.0	0.0	5.14	567.7	0.0
2.001	50.00	4.26	37.480	0.000	0.0	0.0	0.0	2.57	284.2	0.0
2.002	50.00	4.42	36.743	0.000	0.0	0.0	0.0	3.39	374.4	0.0
2.003	50.00	4.58	35.658	0.000	0.0	0.0	0.0	3.83	423.5	0.0
2.004	50.00	4.65	33.947	0.000	0.0	0.0	0.0	4.01	637.7	0.0
2.005	50.00	4.77	33.290	0.000	0.0	0.0	0.0	3.41	541.9	0.0
2.006	50.00	4.88	32.650	0.000	0.0	0.0	0.0	3.39	1498.6	0.0
1.011	50.00	5.54	32.320	0.000	0.0	0.0	0.0	3.28	1966.6	0.0
1.012	50.00	5.65	31.760	0.000	0.0	0.0	0.0	2.66	2287.9	0.0
1.013	50.00	5.73	31.620	0.000	0.0	0.0	0.0	3.63	3118.6	0.0
1.014	50.00	5.86	31.380	0.000	0.0	0.0	0.0	2.99	2568.8	0.0
1.015	50.00	5.94	31.160	0.000	0.0	0.0	0.0	1.78	1525.4	0.0

9 Higher Kingsdown Road

Stoke Road &amp; Deane Rd

Teignmouth

Devon TQ14 9AT

outfall at Victoria Farm

Date Mar 15

Designed by NAS

File Stoke Rd &amp; Deane Rd t...

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Conduit Sections for Storm


NOTE: Diameters less than 66 refer to section numbers of hydraulic conduits. These conduits are marked by the symbols:- [] box culvert, \ / open channel, oo dual pipe, ooo triple pipe, O egg.

Section numbers < 0 are taken from user conduit table

Section Number	Conduit Type	Major Dimn. (mm)	Minor Dimn. (mm)	Side Slope (Deg)	Corner Splay (mm)	4*Hyd Radius (m)	XSect Area (m <sup>2</sup> )
-5	[ ]	1200	500	90.0		0.706	0.600
-6	[ ]	1375	625	90.0		0.859	0.859
-7	_	1040	1640	90.0		1.565	1.643

Manhole Schedules for Storm

MH Name	MH CL (m)	MH Depth (m)	MH Connection	MH Diam., L*W (mm)	PN	Pipe Out Invert Level (m)	Diameter (mm)	PN	Pipes In Invert Level (m)	Diameter (mm)	Backd (mm)
Village Hall inlet	38.530	1.060	Open Manhole	1350	1.000	37.470	450				
GY1	37.510	0.900	Open Manhole	1350	1.001	36.610	450	1.000	36.610	450	
GY2	37.110	0.870	Open Manhole	1350	1.002	36.240	450	1.001	36.240	450	
GY4	36.570	1.080	Open Manhole	1350	1.003	35.490	450	1.002	35.490	450	
Gy5	34.690	0.630	Open Manhole	1350	1.004	34.060	450	1.003	34.060	450	
GY6	34.200	0.640	Open Manhole	1350	1.005	33.560	450	1.004	33.560	450	
GY7	34.040	0.750	Open Manhole	1350	1.006	33.290	450	1.005	33.290	450	
Stream	34.740	1.500	Open Manhole		1.007	33.240	-7	1.006	33.240	450	
MH6420	34.070	0.910	Junction		1.008	33.160	750	1.007	33.160	-7	
MH6416	34.070	1.170	Junction		1.009	32.900	750	1.008	32.900	750	
MH6417	33.910	1.080	Junction	0	1.010	32.830	750	1.009	32.830	750	
Deane Rd inlet	38.634	0.540	Open Manhole	1350	2.000	38.094	375				
MH1	38.430	0.950	Open Manhole	1350	2.001	37.480	375	2.000	37.480	375	
Deane GY1	37.223	0.480	Open Manhole	1350	2.002	36.743	375	2.001	36.743	375	
Deane GY2	36.108	0.450	Open Manhole	1350	2.003	35.658	375	2.002	35.658	375	
Deane GY3	34.827	0.880	Open Manhole	1350	2.004	33.947	450	2.003	33.947	375	
Deane GY4	34.190	0.900	Open Manhole	1350	2.005	33.290	450	2.004	33.290	450	
MH6511	33.840	1.190	Open Manhole	1800	2.006	32.650	750	2.005	32.650	450	
MH6514	33.330	1.010	Open Manhole	3000	1.011	32.320	-5	1.010	32.320	750	
MH6504	32.730	0.970	Open Manhole		1.012	31.760	-6	1.011	31.760	-5	
MH5505	32.770	1.150	Junction		1.013	31.620	-6	1.012	31.620	-6	
MH5515	32.550	1.170	Junction		1.014	31.380	-6	1.013	31.380	-6	
MH5522	32.250	1.090	Junction	0	1.015	31.160	-6	1.014	31.160	-6	
Victoria Farm Ch5524	32.260	1.130	Open Manhole	0		OUTFALL		1.015	31.130	-6	

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9 Higher Kingsdown Road	Stoke Road & Deane Rd	
Teignmouth		
Devon TQ14 9AT	outfall at Victoria Farm	
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PIPELINE SCHEDULES for Storm

Upstream Manhole

PN	Hyd Sect	Diam (mm)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	o	450	Village Hall inlet	38.530	37.470	0.610	Open Manhole	1350
1.001	o	450	GY1	37.510	36.610	0.450	Open Manhole	1350
1.002	o	450	GY2	37.110	36.240	0.420	Open Manhole	1350
1.003	o	450	GY4	36.570	35.490	0.630	Open Manhole	1350
1.004	o	450	Gy5	34.690	34.060	0.180	Open Manhole	1350
1.005	o	450	GY6	34.200	33.560	0.190	Open Manhole	1350
1.006	o	450	GY7	34.040	33.290	0.300	Open Manhole	1350
1.007	_	-7	Stream	34.740	33.240	-0.140	Open Manhole	10000
1.008	o	750	MH6420	34.070	33.160	0.160	Junction	
1.009	o	750	MH6416	34.070	32.900	0.420	Junction	
1.010	o	750	MH6417	33.910	32.830	0.330	Junction	
2.000	o	375	Deane Rd inlet	38.634	38.094	0.165	Open Manhole	1350
2.001	o	375	MH1	38.430	37.480	0.575	Open Manhole	1350
2.002	o	375	Deane GY1	37.223	36.743	0.105	Open Manhole	1350
2.003	o	375	Deane GY2	36.108	35.658	0.075	Open Manhole	1350
2.004	o	450	Deane GY3	34.827	33.947	0.430	Open Manhole	1350
2.005	o	450	Deane GY4	34.190	33.290	0.450	Open Manhole	1350
2.006	o	750	MH6511	33.840	32.650	0.440	Open Manhole	1800
1.011	[ ]	-5	MH6514	33.330	32.320	0.510	Open Manhole	3000
1.012	[ ]	-6	MH6504	32.730	31.760	0.345	Open Manhole	3000
1.013	[ ]	-6	MH5505	32.770	31.620	0.525	Junction	
1.014	[ ]	-6	MH5515	32.550	31.380	0.545	Junction	
1.015	[ ]	-6	MH5522	32.250	31.160	0.465	Junction	

Downstream Manhole

PN	Length (m)	Slope (1:X)	MH Name	C.Level (m)	I.Level (m)	D.Depth (m)	MH Connection	MH DIAM., L*W (mm)
1.000	19.340	22.5	GY1	37.510	36.610	0.450	Open Manhole	1350
1.001	12.800	34.6	GY2	37.110	36.240	0.420	Open Manhole	1350
1.002	27.100	36.1	GY4	36.570	35.490	0.630	Open Manhole	1350
1.003	76.400	53.4	Gy5	34.690	34.060	0.180	Open Manhole	1350
1.004	45.200	90.4	GY6	34.200	33.560	0.190	Open Manhole	1350
1.005	19.100	70.7	GY7	34.040	33.290	0.300	Open Manhole	1350
1.006	1.870	37.4	Stream	34.740	33.240	1.050	Open Manhole	10000
1.007	8.500	106.3	MH6420	34.070	33.160	-0.730	Junction	
1.008	1.560	6.0	MH6416	34.070	32.900	0.420	Junction	
1.009	6.140	87.7	MH6417	33.910	32.830	0.330	Junction	
1.010	11.890	23.3	MH6514	33.330	32.320	0.260	Open Manhole	3000
2.000	7.700	12.5	MH1	38.430	37.480	0.575	Open Manhole	1350
2.001	36.700	49.8	Deane GY1	37.223	36.743	0.105	Open Manhole	1350
2.002	31.200	28.8	Deane GY2	36.108	35.658	0.075	Open Manhole	1350
2.003	38.500	22.5	Deane GY3	34.827	33.947	0.505	Open Manhole	1350
2.004	17.000	25.9	Deane GY4	34.190	33.290	0.450	Open Manhole	1350
2.005	22.900	35.8	MH6511	33.840	32.650	0.740	Open Manhole	1800
2.006	22.500	68.2	MH6514	33.330	32.320	0.260	Open Manhole	3000
1.011	37.930	67.7	MH6504	32.730	31.760	0.470	Open Manhole	3000
1.012	18.280	130.6	MH5505	32.770	31.620	0.525	Junction	
1.013	16.910	70.5	MH5515	32.550	31.380	0.545	Junction	
1.014	22.810	103.7	MH5522	32.250	31.160	0.465	Junction	
1.015	8.770	292.3	Victoria Farm Ch5524	32.260	31.130	0.505	Open Manhole	0

9 Higher Kingsdown Road

Stoke Road &amp; Deane Rd

Teignmouth

Devon TQ14 9AT

outfall at Victoria Farm

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Free Flowing Outfall Details for Storm

<b>Outfall Pipe Number</b>	<b>Outfall Name</b>	<b>C. Level (m)</b>	<b>I. Level (m)</b>	<b>Min I. Level (m)</b>	<b>D,L (mm)</b>	<b>W (mm)</b>
1.015	Victoria Farm Ch5524	32.260	31.130	0.000	0	0

## **APPENDIX E**

### **Catchment Hydrology & Volumes**

1. Catchment adjustments
2. Flow allowances at attenuation locations
3. Deane House flows
4. Village Hall flows
5. The Mead flows
6. Hydrograph volumes by location
7. Storage volumes by location

**CATCHMENT ADJUSTMENTS**

**Deane House**

291950, 70550

Consist of two parts, e/o fields NW of Deane House and Millen compacted track

FEH Catchment area km <sup>2</sup>	1.05
Existing URBEXT	0.0083
or m <sup>2</sup> URBEXT	8715

Additional areas	Factors	Gross	Net
<b>Agriculture</b>	0.1175	NW Millen Lane	85325 <b>10026</b>
Revised catchment km <sup>2</sup>			1.14
Increase catchment to 1.14km <sup>2</sup> from 1.05km <sup>2</sup> and increase EA flows by			<b>8.13</b> %

<b>Compacted tracks (e/o SPR 50-11.75%)</b>	0.3825	Millen Lane	7024	<b>2687</b>
		Total		<b>2687</b>

Revised URBEXT m <sup>2</sup>	11402
Revised URBEXT	0.0114

**Total 2690 m<sup>2</sup> to Windes gives this amount of E/O runoff from compacted Millen Lane**

	RGF	l/s	flow from WinDes
2yr	0.88	36.4	
2.33yr	1.00	41.4	
10yr	1.50	62.0	
25yr	1.98	81.9	
<b>30yr</b>	<b>2.10</b>	<b>86.9</b>	<b>104.2 inc CC20%</b>
50yr	2.44	100.9	
100yr	3.02	124.9	

**Forches Hill**

291552, 70586

Highway areas m<sup>2</sup>      Factors

Length	756	Butterfly Lane to Rock Cottage	2024
Av width	4.0		1000
Area m <sup>2</sup> (@Imp F)	1.0		3024 m <sup>2</sup>

<u>Fields</u>	ha	
Butterfly Lane NE	1.24	
Dagra Lane NW	0.54	
Teighharvey Lane	0.51	
Hillaway	0.17	
<b>Total</b>	<b>2.46</b>	
net (@Imp F)	0.1175	2891 m <sup>2</sup>

<u>Property</u>	m <sup>2</sup>	
Hillaway	350	
net (@Imp F)	0.9	315 m <sup>2</sup>

Total area to consider at Rock Cottage 6230 m<sup>2</sup>  
equivalent to flows of from WinDes

	RGF	l/s	
2yr	0.88	84.4	54.4 flow from WinDes less 30l/s
2.33yr	1.00	95.9	65.9 buddle hole / gate allowance
10yr	1.50	143.9	113.9
25yr	1.98	189.9	159.9
<b>30yr</b>	<b>2.10</b>	<b>201.4</b>	<b>171.4      205.7 inc CC20%</b>
50yr	2.44	234.0	204.0
100yr	3.02	289.6	259.6

Time to fill (minutes): 80.9 MAF  
80m trench, 2m base, 1m deep with 46.8 10yr  
1:2 side slopes max volume 320m<sup>3</sup> 26.1 50yr

**Ivy Tree Hill**

291500, 70554

Highway areas m<sup>2</sup>

Factors

Length (Ivy Tree Cottage to The Lodge)

360 m

Av width

5.0 m

Area m<sup>2</sup> (@Imp F)

1.0

1800 m<sup>2</sup>

Gross

Net

Compacted tracks SPR 50%

0.5

Ridge Rd

3829

1915

Property

m<sup>2</sup>

Fir Tree Cottage to Holly Cottage

427

net (@Imp F)

0.9

384.3 m<sup>2</sup>

Total area to consider at The Lodge  
equivalent to flows of from WinDes

4099 m<sup>2</sup>

flow from WinDes  
less 30l/s buddle hole  
allowance (l/s)

	RGF	l/s	
2yr	0.88	55.5	25.5
2.33yr	1.00	63.1	33.1
10yr	1.50	94.6	64.6
25yr	1.98	124.9	94.9
30yr	2.10	132.4	102.4
50yr	2.44	153.9	123.9
100yr	3.02	190.5	160.5

122.9  
inc CC20%

**Church Lane**

291560, 70534

Highway areas m<sup>2</sup>

Factors

Length

82 m

Av width

3.5 m

Area m<sup>2</sup> (@Imp F)

1.0

287 m<sup>2</sup>

Gross

Net

Compacted tracks SF

0.5

Church Lane

919

460

Property

m<sup>2</sup>

Church Lane

290

net (@Imp F)

0.9

261 m<sup>2</sup>

Total area to consider at Rose Cottage  
equivalent to flows of from WinDes

1008 m<sup>2</sup>

flow from WinDes  
less 30l/s buddle hole  
allowance (l/s)

	RGF	l/s	
2yr	0.88	13.7	
2.33yr	1.00	15.6	
10yr	1.50	23.4	
25yr	1.98	30.8	
30yr	2.10	32.7	39.2
50yr	2.44	38.0	inc CC20%
100yr	3.02	47.0	

39.2  
inc CC20%

<b>Village Hall</b>	291700, 70223	:		
Consists of Green Lane compacted track and fields		:		
		:		
Additional areas	Factors		Gross	Net
Agriculture	0.1175 SW Gabwell Cross		9567	1124
	0.1175 East village hall		27900	3278
		:		
Compacted tracks (e/o SPR 50-11.75%)	0.3825 Green Lane		4472	1711
	Total			<u>6113</u>

Total 6113 m<sup>2</sup> to Windes gives this amout of E/O runoff from compacted Green Lanes agriculture

	RGF	l/s	
2yr	0.88	82.7	flow from WinDes
2.33yr	1.00	94.0	
10yr	1.50	141.0	
25yr	1.98	186.1	
30yr	2.10	197.4	236.8 inc CC20%
50yr	2.44	229.3	
100yr	3.02	283.8	

**Deane Rd - No improvement to existing piped watercourse**

<u>Highway m<sup>2</sup></u>		<u>Factors</u>	
Length		266 to Millen Lane junction	
Av width		5.5	
Area m <sup>2</sup> (@Imp F)	1.0	1463 m <sup>2</sup>	
<u>Property m<sup>2</sup></u>			
gross		1455	
net (@Imp F)	0.9	1309.5	
Total m <sup>2</sup> to Windes		2773	
	RGF	l/s	
2yr	0.88	37.5	
2.33yr	1.00	42.5	
10yr	1.50	63.7	
25yr	1.98	84.2	
30yr	2.10	89.3	107.2 inc CC20%
50yr	2.44	104.0	
100yr	3.02	128.6	

i.e 300ø pipe at minimum gradient has adequate capacity 208 l/s for highway and buildings  
 A discharge of 104 l/s from the road and houses in the 50yr storm is required  
 (Approx CC20% value so that EA flow data can be used to generate hydrograph)  
 Leaving an allowance of 104 l/s to discharge from the watercourse / upstream areas

**Stoke Rd - No improvement to existing piped watercourse**

<u>Highway m<sup>2</sup></u>		<u>Factors</u>	
Length		429 Gabwell Cross to Rose Cottage	
Av width		5.0	
Area m <sup>2</sup> (@Imp F)	1.0	2145 m <sup>2</sup>	
<u>Property m<sup>2</sup></u>			
gross		1326	
net (@Imp F)	0.9	1193	
Total m <sup>2</sup> to Windes		3338	
	RGF	l/s	
2yr	0.88	45.2	
2.33yr	1.00	51.3	
10yr	1.50	76.8	
25yr	1.98	101.5	
30yr	2.10	107.7	129.2 inc CC20%
50yr	2.44	125.3	
100yr	3.02	155.1	

i.e 450ø pipe at minimum gradient has adequate capacity 340 l/s for highway and buildings  
 A discharge of 125 l/s from the road and houses in the 50yr storm is required  
 (Approx CC20% value so that EA flow data can be used to generate hydrograph)  
 Leaving an allowance of 215 l/s to discharge from the watercourse / upstream areas

**- Additional public surface water sewer with highway area to watercourse system**

<u>Highway m<sup>2</sup></u>		<u>Factors</u>	
Length		266 to Millen Lane junction	
Av width		5.5	
Area m <sup>2</sup> (@Imp F)	1.0	1463	
Total m <sup>2</sup> to Windes		1463	
Roof area only			
2yr	0.88	19.8	17.7
2.33yr	1.00	22.5	20.1
10yr	1.50	33.6	30.1
25yr	1.98	44.5	39.7
30yr	2.10	47.2	56.6 inc CC20%
50yr	2.44	54.9	49.1
100yr	3.02	67.9	60.7

i.e 300ø pipe at minimum gradient has adequate capacity 208 l/s for highway and buildings  
 A discharge of 55 l/s from the road in the 50yr storm is required  
 (Approx CC20% value so that EA flow data can be used to generate hydrograph)  
 Leaving an allowance of 153 l/s to discharge from the watercourse / upstream areas

**- Additional public surface water sewer with highway area to watercourse system**

<u>Highway m<sup>2</sup></u>		<u>Factors</u>	
Length		429 to Millen Lane junction	
Av width		5.0	
Area m <sup>2</sup> (@Imp F)	1.0	2145	
Total m <sup>2</sup> to Windes		2145	
Roof area only			
2yr	0.88	29.1	16.1
2.33yr	1.00	33.0	18.3
10yr	1.50	49.4	27.4
25yr	1.98	65.3	36.2
30yr	2.10	69.3	83.2 inc CC20%
50yr	2.44	80.7	44.6
100yr	3.02	99.8	55.2

i.e 450ø pipe at minimum gradient has adequate capacity 340 l/s for highway and buildings  
 A discharge of 81 l/s from the road in the 50yr storm is required  
 (Approx CC20% value so that EA flow data can be used to generate hydrograph)  
 Leaving an allowance of 259 l/s to discharge from the watercourse / upstream areas

## Deane House Hydrographs - adjusted

Adjusted for catchment area

Adjusted for pipe allowance

0.104 m<sup>3</sup>/s

Adjusted pipe allowance

0.153 m<sup>3</sup>/s

No other improvements

Extra SWW sewer pipe for housing

Time	Rtn Period					Time	Rtn Period					Time	Rtn Period					
	2.33	10	25	50	100		2.33	10	25	50	100		2.33	10	25	50	100	
0	0.077	0.063	0.061	0.057	0.057	0						0						
0.205	0.081	0.070	0.070	0.068	0.071	0.205						0.205						
0.41	0.093	0.087	0.093	0.098	0.107	0.41	0.000	0.000	0.000	0.000	0.003	0.41						
0.615	0.116	0.124	0.142	0.158	0.182	0.615	0.012	0.020	0.038	0.054	0.078	0.615	0.000	0.000	0.000	0.000	0.000	0.000
0.82	0.159	0.190	0.231	0.269	0.320	0.82	0.055	0.086	0.127	0.165	0.216	0.82	0.006	0.037	0.078	0.116	0.167	
1.025	0.233	0.307	0.386	0.463	0.561	1.025	0.129	0.203	0.282	0.359	0.457	1.025	0.080	0.154	0.233	0.310	0.408	
1.23	0.351	0.490	0.632	0.768	0.941	1.23	0.247	0.386	0.528	0.664	0.837	1.23	0.198	0.337	0.479	0.615	0.788	
1.435	0.492	0.710	0.926	1.135	1.397	1.435	0.388	0.606	0.822	1.031	1.293	1.435	0.339	0.557	0.773	0.982	1.244	
1.64	0.639	0.940	1.234	1.518	1.873	1.64	0.535	0.836	1.130	1.414	1.769	1.64	0.486	0.787	1.081	1.365	1.720	
1.845	0.776	1.153	1.519	1.873	2.315	1.845	0.672	1.049	1.415	1.769	2.211	1.845	0.623	1.000	1.366	1.720	2.162	
2.05	0.883	1.319	1.742	2.150	2.660	2.05	0.779	1.215	1.638	2.046	2.556	2.05	0.730	1.166	1.589	1.997	2.507	
<b>2.255</b>	<b>0.936</b>	<b>1.402</b>	<b>1.853</b>	<b>2.289</b>	<b>2.832</b>	<b>2.255</b>	0.832	1.298	1.749	2.185	2.728	<b>2.255</b>	0.783	1.249	1.700	2.136	2.679	
2.46	0.920	1.378	1.820	2.248	2.782	2.46	0.816	1.274	1.716	2.144	2.678	2.46	0.767	1.225	1.667	2.095	2.629	
2.665	0.856	1.278	1.687	2.082	2.575	2.665	0.752	1.174	1.583	1.978	2.471	2.665	0.703	1.125	1.534	1.929	2.422	
2.87	0.763	1.132	1.492	1.840	2.273	2.87	0.659	1.028	1.388	1.736	2.169	2.87	0.610	0.979	1.339	1.687	2.120	
3.075	0.653	0.961	1.262	1.554	1.918	3.075	0.549	0.857	1.158	1.450	1.814	3.075	0.500	0.808	1.109	1.401	1.765	
3.28	0.536	0.778	1.018	1.249	1.539	3.28	0.432	0.674	0.914	1.145	1.435	3.28	0.383	0.625	0.865	1.096	1.386	
3.485	0.419	0.597	0.775	0.946	1.163	3.485	0.315	0.493	0.671	0.842	1.059	3.485	0.266	0.444	0.622	0.793	1.010	
3.69	0.313	0.431	0.553	0.670	0.819	3.69	0.209	0.327	0.449	0.566	0.715	3.69	0.160	0.278	0.400	0.517	0.666	
3.895	0.223	0.291	0.365	0.436	0.528	3.895	0.119	0.187	0.261	0.332	0.424	3.895	0.070	0.138	0.212	0.283	0.375	
4.1	0.158	0.189	0.229	0.267	0.318	4.1	0.054	0.085	0.125	0.163	0.214	4.1	0.005	0.036	0.076	0.114	0.165	
4.305	0.118	0.127	0.146	0.164	0.189	4.305	0.014	0.023	0.042	0.060	0.085	4.305	0.000	0.000	0.000	0.011	0.036	
4.51	0.096	0.092	0.100	0.106	0.117	4.51	0.000	0.000	0.000	0.002	0.013	4.51				0.000	0.000	
4.715	0.084	0.074	0.075	0.075	0.079	4.715				0.000	0.000	4.715						
4.92	0.079	0.066	0.064	0.061	0.062	4.92						4.92						
5.125	0.077	0.063	0.061	0.057	0.057	5.125						5.125						

**Village Hall Hydrographs - adjusted**

Adjusted for catchment area

Time	Rtn Period				
	2.33	10	25	50	100
0.000	0.083	0.070	0.063	0.061	0.061
0.223	0.086	0.074	0.069	0.068	0.069
0.446	0.092	0.084	0.083	0.085	0.091
0.669	0.105	0.105	0.110	0.119	0.134
0.892	0.128	0.140	0.158	0.179	0.208
1.115	0.165	0.199	0.237	0.277	0.330
1.338	0.225	0.292	0.362	0.433	0.525
1.561	0.312	0.430	0.547	0.664	0.811
1.784	0.417	0.594	0.769	0.939	1.154
2.007	0.529	0.770	1.005	1.234	1.521
2.230	0.639	0.942	1.237	1.522	1.880
2.453	0.737	1.096	1.444	1.780	2.201
2.676	0.811	1.214	1.601	1.977	2.445
<b>2.899</b>	<b>0.849</b>	<b>1.273</b>	<b>1.681</b>	<b>2.076</b>	<b>2.569</b>
3.122	0.841	1.261	1.665	2.055	2.543
3.345	0.800	1.196	1.577	1.946	2.408
3.568	0.736	1.095	1.442	1.778	2.199
3.791	0.657	0.972	1.276	1.572	1.942
4.014	0.571	0.836	1.094	1.345	1.659
4.237	0.481	0.695	0.905	1.109	1.365
4.460	0.392	0.555	0.717	0.874	1.074
4.683	0.310	0.426	0.542	0.657	0.803
4.906	0.236	0.311	0.387	0.464	0.563
5.129	0.178	0.218	0.263	0.310	0.371
5.352	0.138	0.156	0.180	0.206	0.241
5.575	0.113	0.117	0.127	0.140	0.160
5.798	0.098	0.093	0.095	0.100	0.110
6.021	0.089	0.080	0.077	0.077	0.082
6.244	0.085	0.072	0.067	0.065	0.067
6.467	0.083	0.070	0.063	0.061	0.061
6.690	0.083	0.070	0.063	0.061	0.061

Adjusted for pipe allowance  
No other improvements  
0.115 m³/s  
(0.215 - 0.100 from The Mead)

Time	Rtn Period				
	2.33	10	25	50	100
0.000					
0.223					
0.446				0.000	0.000
0.669	0.000	0.000	0.000	0.004	0.019
0.892	0.013	0.025	0.043	0.064	0.093
1.115	0.050	0.084	0.122	0.162	0.215
1.338	0.110	0.177	0.247	0.318	0.410
1.561	0.197	0.315	0.432	0.549	0.696
1.784	0.302	0.479	0.654	0.824	1.039
2.007	0.414	0.655	0.890	1.119	1.406
2.230	0.524	0.827	1.122	1.407	1.765
2.453	0.622	0.981	1.329	1.665	2.086
2.676	0.696	1.099	1.486	1.862	2.330
<b>2.899</b>	0.734	1.158	1.566	1.961	2.454
3.122	0.726	1.146	1.550	1.940	2.428
3.345	0.685	1.081	1.462	1.831	2.293
3.568	0.621	0.980	1.327	1.663	2.084
3.791	0.542	0.857	1.161	1.457	1.827
4.014	0.456	0.721	0.979	1.230	1.544
4.237	0.366	0.580	0.790	0.994	1.250
4.460	0.277	0.440	0.602	0.759	0.959
4.683	0.195	0.311	0.427	0.542	0.688
4.906	0.121	0.196	0.272	0.349	0.448
5.129	0.063	0.103	0.148	0.195	0.256
5.352	0.023	0.041	0.065	0.091	0.126
5.575	0.000	0.002	0.012	0.025	0.045
5.798		0.000	0.000	0.000	0.000
6.021					
6.244					
6.467					
6.690					

Adjusted pipe allowance  
Extra Sww sewer pipe for housing  
0.159 m³/s  
(0.259 - 0.100 from The Mead)

Time	Rtn Period				
	2.33	10	25	50	100
0.000					
0.223					
0.446				0.000	0.000
0.669				0.000	0.000
0.892	0.000	0.000	0.000	0.020	0.049
1.115	0.006	0.040	0.078	0.118	0.171
1.338	0.066	0.133	0.203	0.274	0.366
1.561	0.153	0.271	0.388	0.505	0.652
1.784	0.258	0.435	0.610	0.780	0.995
2.007	0.370	0.611	0.846	1.075	1.362
2.230	0.480	0.783	1.078	1.363	1.721
2.453	0.578	0.937	1.285	1.621	2.042
2.676	0.652	1.055	1.442	1.818	2.286
<b>2.899</b>	0.690	1.114	1.522	1.917	2.410
3.122	0.682	1.102	1.506	1.896	2.384
3.345	0.641	1.037	1.418	1.787	2.249
3.568	0.577	0.936	1.283	1.619	2.040
3.791	0.498	0.813	1.117	1.413	1.783
4.014	0.412	0.677	0.935	1.186	1.500
4.237	0.322	0.536	0.746	0.950	1.206
4.460	0.233	0.396	0.558	0.715	0.915
4.683	0.151	0.267	0.383	0.498	0.644
4.906	0.077	0.152	0.228	0.305	0.404
5.129	0.019	0.059	0.104	0.151	0.212
5.352	0.000	0.000	0.021	0.047	0.082
5.575			0.000	0.000	0.001
5.798					0.000
6.021					
6.244					
6.467					
6.690					

Adjusted for pipe allowance  
No other improvements  
0.215 m³/s

Time	Rtn Period				
	2.33	10	25	50	100
0.000					
0.223					
0.446					
0.669				0.000	0.000
0.892				0.000	0.000
1.115	0.000	0.000	0.022	0.062	0.115
1.338	0.010	0.077	0.147	0.218	0.310
1.561	0.097	0.215	0.332	0.449	0.596
1.784	0.202	0.379	0.554	0.724	0.939
2.007	0.314	0.555	0.790	1.019	1.306
2.230	0.424	0.727	1.022	1.307	1.665
2.453	0.522	0.881	1.229	1.565	1.986
2.676	0.596	0.999	1.386	1.762	2.230
<b>2.899</b>	0.634	1.058	1.466	1.861	2.354
3.122	0.626	1.046	1.450	1.840	2.328
3.345	0.585	0.981	1.362	1.731	2.193
3.568	0.521	0.880	1.227	1.563	1.984
3.791	0.442	0.757	1.061	1.357	1.727
4.014	0.356	0.621	0.879	1.130	1.444
4.237	0.266	0.480	0.690	0.894	1.150
4.460	0.177	0.340	0.502	0.659	0.859
4.683	0.095	0.211	0.327	0.442	0.588
4.906	0.021	0.096	0.172	0.249	0.348
5.129	0.000	0.003	0.048	0.095	0.156
5.352		0.000	0.000	0.000	0.026
5.575					0.000
5.798					
6.021					
6.244					
6.467					
6.690					

# The Mead Hydrographs - No adjustments required

Adjusted for catchment area

Adjusted for downstream allowance no other improvements 0.100 m<sup>3</sup>/s

Time	Rtn Period					Time	Rtn Period				
	2.33	10	25	50	100		2.33	10	25	50	100
0	0.045	0.037	0.033	0.032	0.032	0					
0.214	0.046	0.04	0.037	0.036	0.038	0.214					
0.428	0.05	0.046	0.045	0.047	0.051	0.428					
0.642	0.058	0.058	0.062	0.067	0.076	0.642			0.000	0.000	
0.856	0.071	0.078	0.088	0.101	0.117	0.856		0.000	0.000	0.001	0.017
1.07	0.091	0.11	0.131	0.153	0.183	1.07	0.000	0.010	0.031	0.053	0.083
1.284	0.122	0.158	0.196	0.234	0.283	1.284	0.022	0.058	0.096	0.134	0.183
1.498	0.165	0.226	0.286	0.347	0.424	1.498	0.065	0.126	0.186	0.247	0.324
1.712	0.223	0.317	0.409	0.5	0.613	1.712	0.123	0.217	0.309	0.400	0.513
1.926	0.291	0.422	0.551	0.676	0.833	1.926	0.191	0.322	0.451	0.576	0.733
2.14	0.36	0.531	0.696	0.857	1.058	2.14	0.260	0.431	0.596	0.757	0.958
2.354	0.424	0.631	0.831	1.025	1.266	2.354	0.324	0.531	0.731	0.925	1.166
2.568	0.475	0.71	0.938	1.158	1.432	2.568	0.375	0.610	0.838	1.058	1.332
<b>2.782</b>	<b>0.504</b>	<b>0.755</b>	<b>0.998</b>	<b>1.233</b>	<b>1.525</b>	<b>2.782</b>	0.404	0.655	0.898	1.133	1.425
2.996	0.504	0.754	0.997	1.232	1.524	2.996	0.404	0.654	0.897	1.132	1.424
3.21	0.479	0.715	0.945	1.167	1.442	3.21	0.379	0.615	0.845	1.067	1.342
3.424	0.437	0.651	0.858	1.059	1.308	3.424	0.337	0.551	0.758	0.959	1.208
3.638	0.386	0.57	0.75	0.924	1.141	3.638	0.286	0.470	0.650	0.824	1.041
3.852	0.328	0.48	0.629	0.773	0.953	3.852	0.228	0.380	0.529	0.673	0.853
4.066	0.268	0.387	0.503	0.617	0.759	4.066	0.168	0.287	0.403	0.517	0.659
4.28	0.21	0.295	0.38	0.463	0.568	4.28	0.110	0.195	0.280	0.363	0.468
4.494	0.158	0.215	0.272	0.329	0.401	4.494	0.058	0.115	0.172	0.229	0.301
4.708	0.117	0.15	0.185	0.221	0.267	4.708	0.017	0.050	0.085	0.121	0.167
4.922	0.088	0.105	0.124	0.145	0.173	4.922	0.000	0.005	0.024	0.045	0.073
5.136	0.069	0.076	0.085	0.096	0.112	5.136		0.000	0.000	0.000	0.012
5.35	0.057	0.057	0.06	0.065	0.073	5.35					0.000
5.564	0.05	0.046	0.045	0.046	0.05	5.564					
5.778	0.046	0.04	0.037	0.036	0.037	5.778					
5.992	0.045	0.037	0.033	0.032	0.032	5.992					
6.467						6.467					
6.69						6.69					

Hydrograph flow volumes by location

**Deane House - No pipe improvements**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.205					0.00
0.41	0.00	0.00	0.00	0.00	1.11
0.615	4.43	7.38	14.02	19.93	29.89
0.82	24.72	39.11	60.89	80.81	108.49
1.025	67.90	106.64	150.92	193.36	248.34
1.23	138.74	217.34	298.89	377.49	477.49
1.435	234.32	366.05	498.15	625.46	785.97
1.64	340.59	532.10	720.29	902.21	1129.88
1.845	445.38	695.57	939.11	1174.53	1468.62
2.05	535.42	835.42	1126.56	1407.74	1759.02
<b>2.255</b>	594.46	927.30	1249.80	1561.24	1949.80
2.46	608.11	949.07	1278.59	1597.40	1994.81
2.665	578.59	903.31	1217.33	1521.02	1899.98
2.87	520.66	812.54	1096.30	1370.47	1712.16
3.075	445.75	695.57	939.47	1175.63	1469.73
3.28	361.99	564.94	764.57	957.56	1198.88
3.485	275.64	430.62	584.87	733.20	920.29
3.69	193.36	302.58	413.28	519.55	654.61
3.895	121.03	189.67	261.99	331.36	420.29
4.1	63.84	100.37	142.43	182.66	235.42
4.305	25.09	39.85	61.62	82.29	110.33
4.51	5.17	8.49	15.50	22.88	36.16
4.715	0.00	0.00	0.00	0.74	4.80
4.92				0.00	0.00
Total volume	5585	8724	11835	14837	18616 m <sup>3</sup>

**Village Hall - No pipe improvements**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.223					0.00
0.446					0.00
0.669	0.00	0.00	0.00	1.61	7.63
0.892	5.22	10.04	17.26	27.30	44.96
1.115	25.29	43.75	66.23	90.72	123.63
1.338	64.22	104.77	148.12	192.67	250.88
1.561	123.23	197.49	272.55	348.01	443.95
1.784	200.30	318.71	435.92	551.12	696.43
2.007	287.40	455.19	619.76	779.92	981.42
2.23	376.51	594.87	807.62	1013.94	1272.84
2.453	460.00	725.73	983.83	1233.10	1545.79
2.676	529.05	834.91	1129.94	1415.74	1772.58
<b>2.899</b>	574.00	905.96	1225.07	1534.55	1920.30
3.122	586.04	924.83	1250.76	1565.86	1959.63
3.345	566.38	893.92	1209.02	1513.68	1895.01
3.568	524.23	827.29	1119.50	1402.49	1756.93
3.791	466.83	737.37	998.68	1252.37	1569.88
4.014	400.60	633.41	859.00	1078.56	1353.12
4.237	329.95	522.22	710.08	892.71	1121.51
4.46	258.10	409.43	558.75	703.65	886.69
4.683	189.46	301.45	413.04	522.22	661.11
4.906	126.84	203.51	280.58	357.65	455.99
5.129	73.86	120.02	168.59	218.36	282.59
5.352	34.52	57.80	85.50	114.80	153.33
5.575	9.23	17.26	30.91	46.56	68.64
5.798	0.00	0.80	4.82	10.04	18.06
6.021	0.00	0.00	0.00	0.00	0.00
Total volume	6211	9841	13396	16868	21243 m <sup>3</sup>

**The Mead - No improvements**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.214					0.00
0.428					0.00
0.642				0.00	0.00
0.856		0.00	0.00	0.39	6.55
1.07	0.00	3.85	11.94	20.80	38.52
1.284	8.47	26.19	48.92	72.03	102.46
1.498	33.51	70.88	108.63	146.76	195.30
1.712	72.42	132.12	190.67	249.22	322.41
1.926	120.95	207.62	292.75	375.96	479.96
2.14	173.73	290.06	403.30	513.47	651.37
2.354	224.96	370.56	511.16	647.91	818.16
2.568	269.25	439.51	604.38	763.85	962.23
<b>2.782</b>	300.07	487.28	668.71	843.97	1062.00
2.996	311.24	504.23	691.43	872.48	1097.43
3.21	301.61	488.82	671.02	847.05	1065.46
3.424	275.80	449.14	617.48	780.42	982.26
3.638	239.98	393.29	542.36	686.81	866.31
3.852	197.99	327.42	454.15	576.64	729.57
4.066	152.54	256.93	359.01	458.39	582.42
4.28	107.09	185.67	263.09	338.98	434.12
4.494	64.71	119.41	174.11	228.04	296.22
4.708	28.89	63.56	99.00	134.82	180.27
4.922	6.55	21.19	41.99	63.94	92.45
5.136	0.00	1.93	9.24	17.33	32.74
5.35		0.00	0.00	0.00	4.62
5.564					0.00
5.778					
5.992					
Total volume	2890	4840	6763	8639	11003

Hydrograph flow volumes by location

**Deane House - With SWW pipe improvements**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.205					
0.41				0.00	0.00
0.615	0.00	0.00	0.00	0.00	0.00
0.82	2.21	13.65	28.78	42.80	61.62
1.025	31.73	70.48	114.76	157.19	212.18
1.23	102.58	181.18	262.73	341.33	441.32
1.435	198.15	329.89	461.99	589.29	749.81
1.64	304.43	495.94	684.13	866.04	1093.72
1.845	409.22	659.40	902.94	1138.37	1432.46
2.05	499.26	799.25	1090.40	1371.57	1722.86
<b>2.255</b>	<b>558.30</b>	<b>891.14</b>	<b>1213.64</b>	<b>1525.08</b>	<b>1913.63</b>
2.46	571.95	912.91	1242.42	1561.24	1958.65
2.665	542.43	867.15	1181.17	1484.86	1863.82
2.87	484.50	776.38	1060.14	1334.30	1676.00
3.075	409.59	659.40	903.31	1139.47	1433.57
3.28	325.83	528.78	728.41	921.39	1162.72
3.485	239.48	394.46	548.70	697.04	884.12
3.69	157.19	266.42	377.12	483.39	618.44
3.895	84.87	153.50	225.83	295.20	384.13
4.1	27.68	64.21	106.27	146.49	199.26
4.305	1.85	13.28	28.04	46.13	74.17
4.51	0.00	0.00	0.00	4.06	13.28
4.715				0.00	0.00
Total volume	4951.2	8077.4	11160.8	14145.2	17895.8 m <sup>3</sup>
diff	633.9	646.5	673.8	692.2	720.3 m <sup>3</sup>

**Village Hall - With SWW pipe improvements**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.223					
0.446				0.00	0.00
0.669	0.00	0.00	0.00	8.03	19.67
0.892	2.41	16.06	31.31	55.39	88.31
1.115	28.90	69.44	112.79	157.35	215.55
1.338	87.91	162.17	237.23	312.69	408.63
1.561	164.98	283.39	400.60	515.80	661.11
1.784	252.08	419.86	584.44	744.60	946.10
2.007	341.19	559.55	772.29	978.61	1237.52
2.23	424.68	690.41	948.51	1197.78	1510.47
2.453	493.72	799.59	1094.62	1380.41	1737.26
2.676	538.68	870.64	1189.75	1499.23	1884.97
<b>2.899</b>	<b>550.72</b>	<b>889.50</b>	<b>1215.44</b>	<b>1530.54</b>	<b>1924.31</b>
3.122	531.05	858.59	1173.69	1478.36	1859.69
3.345	488.91	791.96	1084.18	1367.17	1721.60
3.568	431.51	702.05	963.36	1217.04	1534.55
3.791	365.27	598.09	823.67	1043.24	1317.80
4.014	294.63	486.90	674.75	857.39	1086.19
4.237	222.78	374.10	523.43	668.33	851.37
4.46	154.14	266.13	377.72	486.90	625.78
4.683	91.52	168.19	245.26	322.32	420.67
4.906	38.53	84.70	133.26	183.04	247.26
5.129	7.63	23.68	50.18	79.48	118.01
5.352	0.00	0.00	8.43	18.87	33.32
5.575			0.00	0.00	0.40
5.798					0.00
Total volume	5511.2	9115.0	12644.9	16102.6	20450.5 m <sup>3</sup>
diff	700.0	725.7	750.6	765.1	769.4 Average
					792.4 m <sup>3</sup>

**Village Hall - With pipe enlarged from 450mm to 525mm**

Time	Rtn Period				
	2.33	10	25	50	100
0					
0.223					
0.446					
0.669					
0.892			0.00	0.00	0.00
1.115	0.00	0.00	8.83	24.89	46.16
1.338	4.01	30.91	67.84	112.39	170.60
1.561	42.95	117.21	192.27	267.73	363.67
1.784	120.02	238.43	355.64	470.84	616.15
2.007	207.12	374.91	539.48	699.64	901.14
2.23	296.23	514.59	727.34	933.66	1192.56
2.453	379.72	645.45	903.55	1152.82	1465.51
2.676	448.77	754.63	1049.66	1335.46	1692.30
<b>2.899</b>	493.72	825.68	1144.79	1454.27	1840.02
3.122	505.76	844.55	1170.48	1485.58	1879.35
3.345	486.10	813.64	1128.74	1433.40	1814.73
3.568	443.95	747.01	1039.22	1322.21	1676.65
3.791	386.55	657.09	918.40	1172.09	1489.60
4.014	320.32	553.13	778.72	998.28	1272.84
4.237	249.67	441.94	629.80	812.43	1041.23
4.46	177.82	329.15	478.47	623.37	806.41
4.683	109.18	221.17	332.76	441.94	580.83
4.906	46.56	123.23	200.30	277.37	375.71
5.129	8.43	39.74	88.31	138.08	202.31
5.352	0.00	1.20	19.27	38.13	73.05
5.575		0.00	0.00	0.00	10.44
5.798					0.00
Total volume	4726.9	8273.7	11773.9	15194.6	19511.3 m <sup>3</sup>
diff	1484.4	1567.1	1621.7	1673.0	1731.6 m <sup>3</sup>

1675.4 Average



**5.0 FURTHER SURVEY AND STUDY REQUIRED**

- a) Obtain copy of Teignbridge District Council infiltration study undertaken for SWW and consider against flood alleviation options;
- b) An inspection of the planning file for Hollifields, Lower Gabwell and the properties in Ivy Tree Hill;
- c) Obtain copies of utility records for Deane Road, Ivy Tree Hill and Stoke Road: BT, WPD, and WWU;
- d) Investigate blockage to arch culvert at Home Farm Court;
- e) Survey watercourse, manhole and pipe branch entering MH5504 from Church House Inn;
- f) CCTV camera and level survey of the pipe system between Hilary Cottage and The Firs;
- g) Topographical survey of land adjacent to and south of Deane House identified for flood storage and cut off ditches;
- h) Topographical survey of Deane Road if additional gullies are to be constructed;
- i) BRE 365 Infiltration tests at Teignharvey Lane if infiltration is to be considered;
- j) CCTV survey of gullies and pipes in Ivy Tree Hill Stoke Cross to determine capacity;
- k) Open MH5521 or MH5524 to confirm depths and connectivity;
- l) Topographical survey of land between Village Hall and Pools Weir Road identified for flood storage. This should include SWW MH cover levels, invert levels and pipe branches even if chambers are buried;
- m) Topographical survey of land between Hilary Cottage and The Mead if insufficient volume is available between the Village Hall and Pools Weir Road.