Derby City Council

Derby City Council
Surface Water Management Plan

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JOB NUMBER: LD10038		DOCUMENT REF: LD10038 DRAFT July '11.doc				
Revision	Description	Originated	Checked	Reviewed	Authorised	Date
01	Draft	NT/MHB	KT	DB	PR	

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1 Executive Summary

This document forms the draft Surface Water Management Plan (SWMP) for the Unitary Authority of Derby City. The study is the continuation of an ongoing commitment to improve the drainage infrastructure of the city and so reduce flooding throughout. It is also the first step in a move initiated as part of the Water Framework Directive, the Flood Risk Regulations (2009) and the Floods and Water Management Act (2010) to:

- increase understanding into the causes, probability and consequences of surface water flooding
- increasing the awareness of public, partners and stakeholders into the duties and responsibilities of managing flood risk
- develop coordinated action plans to identify and mitigate surface water flooding
- encourage the use of Sustainable urban Drainage Systems (SuDS) in reducing flood risk.

Derby lies at the confluence of the Rivers Trent and Derwent and has a recorded history of flooding stretching back some 400 years. It has a number of contributing watercourses flowing through an intensely urbanised catchment and parts of the city are very vulnerable to flooding. Various of these have been modelled in the past, however the quality and scope of these reports varies significantly.

In common with many other historic urban environments much information relating to surface water or highway drainage has been lost over time, resulting in a significant lack of data. Currently the council is embarking on major investigation works to recover this lost knowledge, this involves tracing existing road gullies and highway drainage systems and developing a dedicated asset register.

Ground tracing radar assessment, based on aerial photography has been used to map ground contours, however recent construction works, such as the new inner ring road, mean that much of this is now out of date

Because of the above point, the following report has been set at the **Strategic** level to act as a primarily information gathering exercise.

Future actions have been planned to advance the knowledge base of the surface water flooding potential of Derby, and so allow us to anticipate mitigate future flooding, and also to advise developers and other stakeholders of the relevant risks associated with their environment. These include:

- the better management of highway gulley cleansing
- the creation of a citywide integrated drainage model, to include the major and minor watercourses
- renewal of the LiDAR topographic map
- giving current and timely advice to developers on SuDS systems for use in Derby
- the development of an easily understandable and straightforward means of recording flooding including a data entry form suitable for use by the public

2 Glossary and Definitions

Term	Definition or meaning
AAP	Annual Average Probability – The chance of a flood or rainfall event occurring in a given year, normally expressed as a percentage. (i.e. 2% AAP means an event with a 2% chance of occurring in any year)
AStSWF	Areas Susceptible to Surface Water Flooding – a GIS database designed to indicate flooding from rainfall
Attenuation	A device or system designed to store flows or flood waters thus reducing the downstream effects and increasing the duration of overall flows.
Balancing Pond	A pond or lake designed to accept unrestricted flood flows and to pass them forward at a controlled or managed flow rate, the excess being stored within the pond. A form of flood attenuation.
Brownfield Site	An area of land which has been previously developed
Catchment	The area of land contributing flow or runoff to a particular point or node on a watercourse system
Climate Change	Projected long-term variations in weather patterns, principally concerning extremes of temperature and rainfall. Thought to be connected with the increasing global emissions of carbon dioxide.
Cumec	A method of measurement for fluids, corresponding to cubic metres per second.
DCC	Derby City Council
Defra	Department for Food and Rural Affairs
Design Criteria	A set of standards used as the basis for a development or construction which is deemed to satisfy the requirements of the various regulatory and approving bodies permitting the development.
Design Event	An historic or notional rainfall event against which the drainage design of a development is measured.
Design Flood Level	The maximum estimated water level resulting from a design event.
Detention Basin	A recessed area, dry under normal conditions, which may be allowed to flood during heavy rainfall. Is used to attenuate runoff from a particular catchment.
Drain	A private conduit used to convey storm or foul sewerage from a single point of origin to a point of disposal.
EA	Environment Agency
FMfSW	Flood Maps for Surface Water – a GIS system designed to demonstrate the effects and flow paths of surface water flooding resulting from rainfall.
Filter Drain or Trench	A trench filled with permeable material, usually incorporating a porous pipe, used to store, transfer and infiltrate water into the ground.
Filter Strip	Area of flat or gently sloping vegetated ground which is used to convey surface runoff to a drain or filter drain.
Filtration	The act of separating suspended solids from water by passing it through a filter membrane. Used to collect pollutants.
First Flush	The initial runoff from a site or catchment following rain. This runoff tends to carry with it surface bound pollutants
Flooding	This may be defined as the inundation of residential and commercial properties and infrastructure that causes damage and disruption.
Flood Defence	Type of physical infrastructure such as walls or embankments, used to protect an area from flooding.
Flood Risk	The vulnerability of an area based upon the combination of probability and consequences of flooding.
Flood Risk Assessment	A study to evaluate the potential for flooding, of a particular site, and the resulting impacts of such an event.

Flow Control Device	A physical device used to limit or control the forward flow of water through a point.
Fluvial Flow	Directly associated with a stream, brook or river
GIS	Geographic Information System
Greenfield	Land which is previously undeveloped or in a natural state
Groundwater	Water which occurs below ground level. The upper level of this is generally referred to as the Water Table and is often, but not always parallel to ground level.
Groundwater Flooding	When groundwater rises above ground level it may affect natural hollows or excavations.
Hydrograph	Graph showing the flow of water over time, in a drainage system or watercourse.
Impermeable Surface	Artificial or paved surface which forms a barrier to the infiltration of water (e.g. concrete, tarmac)
Infiltration	The passage of water into the ground
Infiltration Basin	A dry recessed area aimed at encouraging the flow of water into the ground.
LLFA	Lead Local Flood Authority
LIDAR	Light Detection and Ranging – a system of determining ground contours
Local Development Strategy	Document and plans which outline the authority's future development Strategy.
Main River	Any stream, brook or watercourse for which the Environment Agency is the managing authority
NRPD	National Receptor Property Dataset
Ordinary Watercourse	Any stream, brook or river NOT considered to be main river or private drain, lies under the direct control of the local drainage authority
Overland Flow	Water flowing over the ground. This may arise directly from rainfall or inundated underground drainage. Surface runoff will follow the easiest route to the lowest point.
Permeable Paving and Porous Surfacing	Surfacing which has perforations or gaps allowing the movement of surface water through to the layers below. This will then tend to flow through the granular base material to a suitable drainage system or will infiltrate into the soil below.
PFRA – (Preliminary Flood Risk Assessment)	A high level study to identify and assess the general flood risks affecting a given local authority administrative area. Driven by the EU.
PPS25 – (Planning Policy Statement 25)	A high level document aimed at guiding planning authorities and thus development away from vulnerable or inappropriate land.
Pluvial Flow	Flow directly associated with rainfall
Rainwater Harvesting	A system of management for roof water which allows for the filtering and reuse of the collected water for such uses as toilet flushing and laundry.
Retention Pond	A drainage feature where rainwater is retained long enough for solids to settle out before discharge. Also allows the biological treatment of some pollutants if retention time is sufficiently long.
Riparian Ownership	The ownership of land containing, or adjacent to, a watercourse. Riparian ownership conveys certain rights and responsibilities relating to the management of the watercourse in question.
SFRA - (Strategic Flood Risk Assessment)	A high level study to identify and assess the definitive flood risks affecting a given local authority administrative area
Runoff	Water flowing above ground before entering the local sewer system.
Severn Trent Water (STW)	Local sewerage undertaker for the Derby area. They are responsible for the treatment and disposal of foul and surface water from all adopted sewers.
Sewer	A pipe or conduit used to convey excess rainwater or sewerage from multiple sources to a point of disposal.

Standard of Protection (SoP)	Refers to the lowest probability of event liable to produce flooding over and above any protection or mitigation features. Often given in terms of a number of years (e.g. 25, 50 or 100 year).
Storage Pond	A permanently wet feature used to store water in times of heavy rainfall.
SuDS	Sustainable urban Drainage System – an approach to the management of rainwater on new developments aimed at reducing the impact of the development on the existing drainage network and local environment.
Surface Water Management Plan (SWMP)	A high level framework agreement through which key local partners with responsibility for surface water and drainage can work together to understand the causes of surface water flooding and agree the most effective way of managing surface water flood risk.
Swale	A shallow trench or ditch with very gently sloping sides used to collect, convey and store runoff. An element of treatment and infiltration is also generally offered.
Time of entry	The time taken for water falling on a surface, to enter the drain or sewer system.
Time of concentration	The time taken for water to travel from the furthest point of the catchment area to the junction with another catchment.
UKRLG	United Kingdom Roads Liaison Group

3 Introduction

3.1 Background

Flooding events in April 1998 (Midlands), November 2000 (Midlands), January 2005 (Carlisle) and June/July 2007 (Midlands & Yorkshire) resulted in a large number of properties being inundated due to fluvial, pluvial and sewer flooding – in some cases from more than one source. In response to these events, the government commissioned a series of reviews and reports to examine the flood risk management procedures, strategies and state of protection offered to vulnerable properties. The resulting reports and guidance documents have given us a wealth of information and guidance on the management of our respective towns and cities. These documents include:- “Learning to Live with Rivers” (2001)[1], “Making Space for Water (2005)[2], PPS25 “Development and Flood Risk” (2006)[3] and The Pitt Review ”Lessons learned from the 2007 floods” (2008)[4], and have all identified the need for a holistic and integrated approach to flood risk management generally and, in particular, the need for an integrated approach to urban drainage.

Between 2007 and 2009 DEFRA initiated 15 Integrated Urban Drainage (IUD) pilot studies to examine the various aspects of IUD management across a range of urban catchments which had previously suffered flooding. These studies incorporated surface water runoff, sewers and fluvial channels, and also involved developing partnerships, sharing data, surface water modelling approaches, mitigation measures and strategic surface water drainage approaches for new developments. The primary outcome of these studies was the development of a “Living Draft” Surface Water Management Plan Guidance, which was tested by applying six “first edition” SWMPs for Gloucestershire, Hull, Leeds, Richmond & Kingston, Thatcham and Warrington. The final guidance produced as a result of this process now forms the basis of all new SWMPs currently being produced.

Surface Water Flooding is defined as flooding from sewers, drains and small watercourses which occurs during heavy rainfall in urban areas. It includes:

- Fluvial flooding - flooding from small open channel, or open or culverted watercourses which accept flow from within the urbanised catchment.
- Pluvial flooding – flooding occurring as a result of high intensity rainfall which collects and ponds or flows over the surface before entering the underground network or adjacent watercourse, or flows over the ground because it cannot enter the network
- Sewer flooding arising as a result of the capacity of the system being exceeded and further water “backing up”. Capacity problems may arise if the receiving waters are too high, or if recent developments have resulted increases in runoff to the system.
- Flooding and/or overland flows resulting from groundwater sources, where groundwater is defined as all water which is located below the ground and is in contact with the ground or subsoil.
- Overland flows from outside the nominal catchment or authority boundary, including water from springs.

3.2 The Lower Derwent Flood Risk Management Strategy

The Environment Agency first released the Lower Derwent Strategy as a public consultation document in September 2008, the final strategy was published in January 2011 following relevant consultation. The main thrust of the strategy is to reduce flood risk across the Lower Derwent catchment (including Derby) over the next 100 years. However the strategy is also designed to offer wider environmental and social benefits. The strategy concentrates predominantly on fluvial flooding from the River Derwent which is beyond the scope of this assessment; however the proposed activities could influence surface water flood risk.

The activities proposed are grouped into three categories as follows:-

1. Continue and review existing activities
   The actions proposed in this category are generally a continuance of existing activities which are undertaken to reduce fluvial flood risk from main rivers including the River Derwent which will have little impact on surface water flood risk within Derby.
   The exception to this is the proposal to control development through the use of PPS25 and to "continue to encourage the use of SuDS" which has the potential to reduce surface water flood risk within the city by controlling surface water discharge from new development and development on brownfield sites.

2. Upstream land use and management
   The activities within this category are generally intended to reduce runoff from undeveloped land through encouragement of appropriate land management techniques. This in turn will lead to reduced flows in watercourses. It is likely that this will reduce surface water flood risk where such watercourses enter the city.

3 Provide flood defences and improve conveyance
   The actions proposed that impact direct on Derby City include: -

   - improving flow through Derby Junction Railway Bridge (Five Arches Bridge)

   - align defences to a new line through Derby City Centre to the optimum standard of protection. This is the category that offers the greatest potential for protecting properties from fluvial flood risk from the River Derwent within Derby City however the proposals also impact on surface water flood risk.

Both above actions will lead to reduced peak water levels in the River Derwent which in turn will improve the efficiency of the sewer network by reducing sewer surcharge levels at submerged outfalls and therefore in this respect will reduce surface water flood risk to large areas of Derby. In contrast the raising and realignment of flood defences can interrupt surface water flood flow paths, with the possibility of increasing surface water flood risk in localised areas.
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3.3 Funding

As part of the government response to the Pitt Review, Ministers announced investment of £15 million to help 77 local authorities co-ordinate and lead local flood management work and develop individual SWMPs. Being considered the 17th most at risk authority in the country, Derby City was awarded funding for the development of its own SWMP.

3.4 SWMP Framework Programme

Typically, there are four phases to the delivery of a Surface Water Management Plan, these are respectively:-

- **Preparation** – The defining of a basic need for a SWMP, developing the requisite partnerships, and setting the scope and limits of the study.
- **Risk Assessment** – The undertaking of preliminary, intermediate and detailed Risk Assessments, and the mapping and consultation on areas at risk.
- **Options** – The identification and assessment options for the mitigation of surface water flooding in order to identify preferred options.
- **Implementation** – The preparation and implementation of action plans to mitigate and reduce the occurrence and effects of surface water flooding.

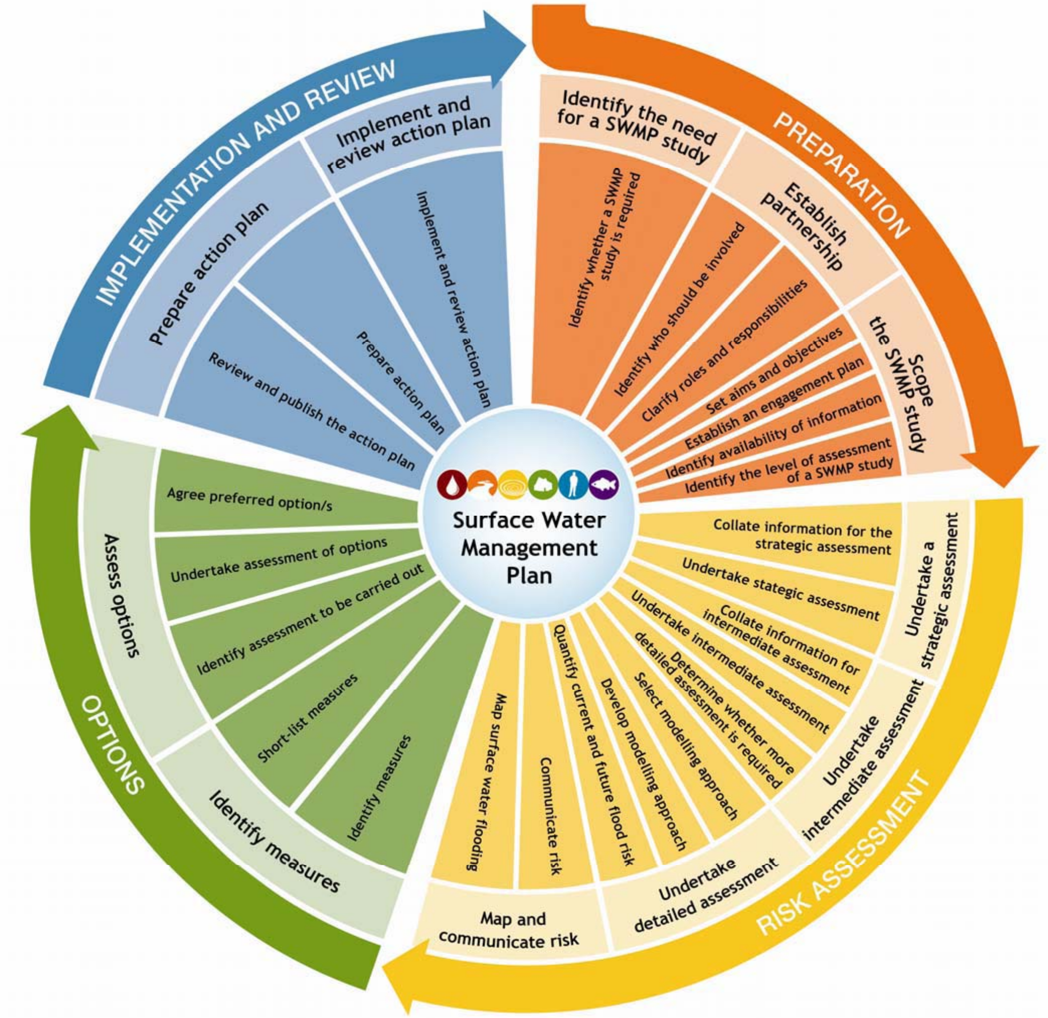

Figure 3.1 Wheel diagram of SWMP phasing

4 Preparation

4.1 Study Area

The city of Derby covers an area of some 30sq. miles and has a population of approximately 244,000[5]. It is situated on the banks of the River Derwent just to the north of its confluence with the River Trent, the influence of this union dominates the topography of the city.

The R. Derwent enters the city from the north in a steep sided relatively narrow valley, with the high ground of Darley Abbey and Allestree on the west bank and Chaddesden on the east bank. As it progresses through Derby city centre, the R. Derwent veers to the east and the valley broadens as it approaches its confluence with the R. Trent. To the south of the city, the land is generally flat with much marshy land lining the banks of the R. Trent and the adjacent Trent and Mersey Canal. The wards of Alvaston, Boulton and Sinfin are particularly notable for this land feature and are known to have high groundwater levels throughout.

The city is bounded to the north by Amber Valley and Erewash District Councils, and on the south by South Derbyshire District Council The following illustration shows the city extents and ward boundaries.

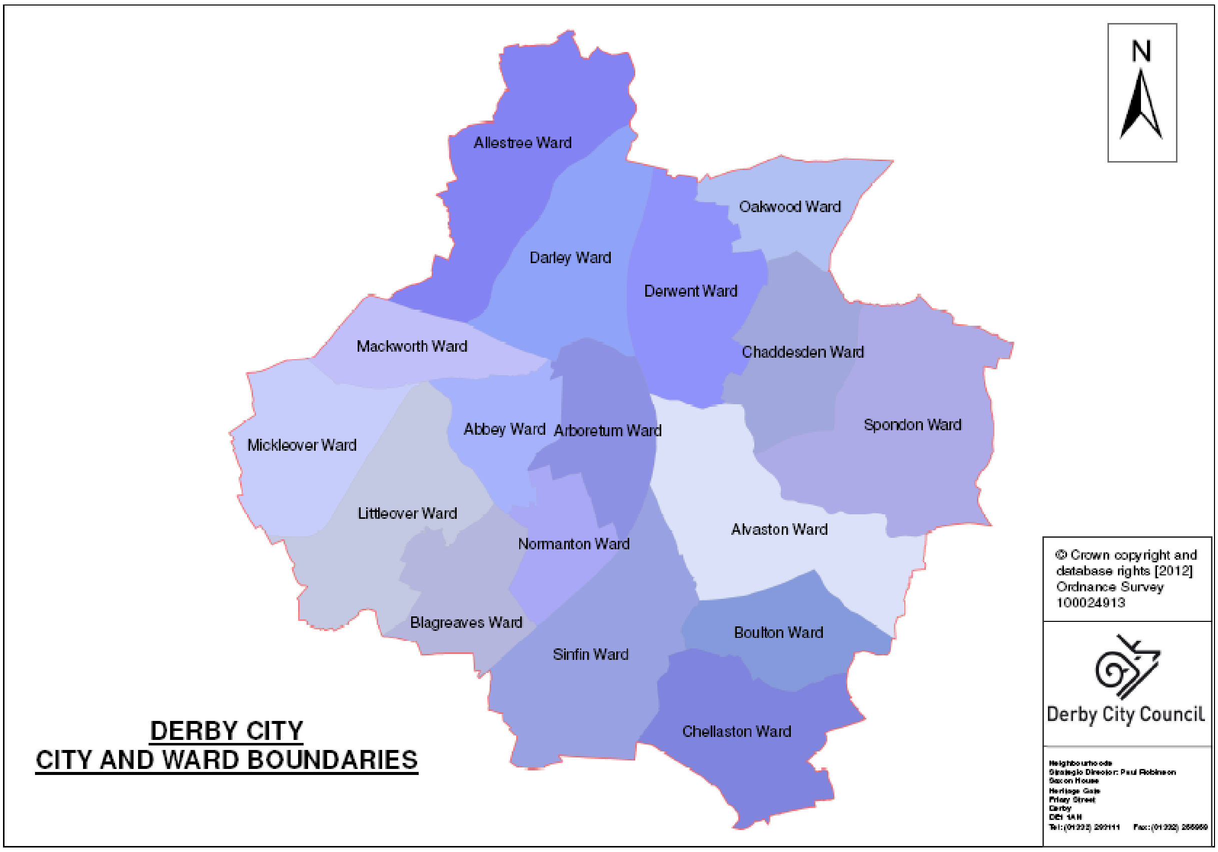

Figure 4.1 – Derby City Extents and Ward Boundaries

There are a number of minor and ordinary watercourses which feed through the city in a mixture of open and culverted sections, some of which have been either wholly or partially enmained by the Environment Agency, and some have been adopted by Severn

Trent Water (STW) as a result of historic connections. These are listed later in the report together with descriptions of their respective catchments and susceptibility to flooding.
Derby has a long history of flooding, dating back to the early 1600's most of the recorded events describe flooding from the R. Derwent or one of the major brook courses, and include the inundation of residential development, critical highway infrastructure and the occasional loss of life.
Sources of flooding are primarily fluvial and pluvial, Derby does not currently have a functional canal and there is very little historical evidence of direct groundwater flooding.
On the basis of historical occurrences, it is considered both necessary and appropriate to complete a SWMP for the city, and as outlined Derby has received funding on this basis.

4.2 Partners

A number of agencies have currently been identified as consultees to the SWMP process, some because they have a direct impact on the control, likelihood and occurrence of flooding or flooding impacts within the city, and some because their administrative areas border those of the city. Outside of Derby City Council the primary local flood risk management authorities include the following partner organisations:-

4.2.1 Severn Trent Water

The adopted foul and surface water sewer systems in Derby are the responsibility of Severn Trent Water. The system is monitored by means of routine inspections, planned CCTV surveys, installed telemetry at key assets (i.e. pumping stations) and a small number of long term system monitors. It should be noted, however owing to the extent of the overall network, a significant reliance is placed upon reports from external organisations, including the general public.
The sewer network dates back over many decades, and has been designed to a variety of standards. Sewers for Adoption (a design guide for developers seeking the adoption of sewer systems) recommends that storm sewers should be designed to accept storm events up to a 3.33% AAP (1 in 30 years) however this is not true of all sewers and the Standard of Protection (SoP) does differ in certain areas. This is particularly the case for older combined sewers (taking both storm and foul sewage). In addition, increasing urban development and intensification can increase flows draining to the existing sewer system and result in increased risk of flooding under extreme conditions.
As part of their business strategy, agreed with OFWAT, Severn Trent Water have a requirement to record incidents of internal or curtilage flooding on a confidential register (known as DG5) and are able to apply for permission to spend capital funds to improve those properties or areas most vulnerable to frequent flooding. As a private company STW raises finance for capital schemes through the revenue streams of service bills and water rates. It should be noted that new private development requires specific design to accommodate events of up to 1% (1 in 100 years) without passing on flooding and requires a further design check to include for the anticipated effects of climate change.

4.2.2 Environment Agency

The Environment Agency (EA) is the national organisation tasked with the management of flood risk from main rivers and coastal sources. They are a partner in the SWMP process and serve as a source of datasets and other supporting data, and as a coordinator between the upper tier authorities involved in the production of SWMPs. The EA are responsible for the management of the R. Derwent through Derby, and also a number of the minor watercourses designated as "Main River" through the city. These watercourses include all of the Chaddesden and Cotton Brooks and part of the Markeaton, Hell, Cuttle and Thulston Brooks.

4.2.3 Highways Agency

The Highways Agency are responsible for managing the status of the trunk roads around Derby. These consist of the A38(t) on the west of the city, the A6(t) from the A50 to the A52 in the south; and the A52(t) from Spondon to the city's eastern boundary. Requests have been made for information confirming the above and requesting information associated with flood risk strategy within the highway network. To date no assistance has been received.

4.2.4 Derbyshire County Council and associated Boroughs

Derby has an ongoing relationship with Derbyshire County Council and is represented on Local Strategic Planning and Flood Boards at the county level. We have good relations with the surrounding borough councils and thus minimise the potential for cross border disputes. Adjacent borough authorities include South Derbyshire, Amber Valley and Erewash.

In addition to the above, we have an ongoing relationship with the following groups:-
Derby Police service
Derbyshire Fire and Rescue Service
Derby emergency planners
Derby development planners

4.3 Data Sources

For the presentation of SWMP data it is proposed to use a GIS database platform. This will allow flood data to be freely available to assist a variety of functions within the council. Data has been collected from a number of sources and will be regularly updated on this media to form a growing database of flooding information. This will enable the development of evolving strategies to predict flood events and hopefully adopt preventative measures. The following is a list of data gathered in the development of this SWMP.

Table 4.1 Sources of data

Data source	Nature of Data	Description
Environment Agency	LiDAR surveys	Surface elevation data & DTM from flown photographic survey data.
	EA Fluvial Flood Maps	Standard flood maps depicting defined flood zones
	Historic Flood Maps	Recorded historical flood data.
	Areas Susceptible to Surface Water Flooding (AStSWF)	Based on LiDAR. Pluvial flooding based on a single summer event of 0.5% AAP (1 in 200 year probability) of 6.5 hours duration but making no allowance for buildings or sewers.
	Flood Maps for Surface Water (FMfSW)	Based on LiDAR, but with added OS Mastermap layouts. Uses two storm events, the 0.5% event as above, plus a second 3.33% AAP (1 in 30 year) event of 1.1 hour duration. Also, this model takes account of building footprints, makes allowance for sewers and offers infiltration rates for rural (61%) and urban (30%) environments.
	National Receptor Property Dataset	Shows property types and numbers of individual properties to enable fiscal and critical assessment of flood risk.

Data source	Nature of Data	Description
Derby City Council	Strategic Flood Risk Assessment	Prepared for Derby and approved by EA for general issue
	Flooding Hotspots List	From Derby Records
	Historic Flood Areas	From Derby Records
	Watercourse Original Line	Local Derby Records and historic maps
Severn Trent Water	DG5 Sewer Information	Records of property flooding from sewers.
		Condition and capacity survey of existing sewers.
British Geological Survey	Susceptibility to groundwater flooding	Details of groundwater levels as affected by drift and solid geology. Presented as a GIS layer.

Data Gathering
Internally collated Derby information relating to water and drainage related infrastructure includes the following:-

Table 4.2 Water Management Features

Feature	Quantity
Culverted Watercourse Identified	41.0 km
Culvert Manholes	600 No.
Inlet Structures	209 No.
Screens	44 No.
Outfall Structure	200 No.
Open Watercourse Identified	100.0 km
Highway Drainage Located	46.0 km
Kerb Drainage	1.6 km
Highway Manholes	902 No.
Gullies	40000No.
Highway Interceptors	41 No.
Flow Control Structures	4 No.
Flap Valves	3 No.
Penstocks an Sluices	3 No.
Balancing Areas	19 No.
Ponds	12 No.
Weirs	23 No.

4.4 Aims and Objectives

The aims of the SWMP are:-

- To raise awareness of flood risk for members of the public
- To undertake an assessment of local flood risk within the confines of the city boundary with respect to past flooding and the potential harmful consequences of future flooding.
- To produce an action plan to reduce the effects and consequences of flooding to the people, properties and essential infrastructure of Derby.

It should, however, be noted that the city lies wholly within the boundaries of Derbyshire, and its boundaries abut those of the boroughs of Amber Valley, Erewash and South

Derbyshire. With this in mind the study must also consider the risks to, and from, these neighbouring areas as a result of existing and future development.

The main objectives are to:
- assess available information in order to map and quantify the number of properties at risk from surface water flooding
- work with partners to identify the likely sources, pathways and receptors of surface water flooding, and so gain an improved understanding of the mechanisms involved together with the location, ownership, condition and purpose of surface water infrastructure within Derby
- identify and assess risks and impacts resulting from proposed future development and climate change. Work with partners to challenge unsustainable growth in areas where this may adversely affect existing properties and infrastructure
- prepare strategies to reduce the number of properties at risk together with a programme to implement this over a prescribed time period
- prepare suitable plans showing surface water flood risk for use by flood resilience forums and city planners
- arrange for ongoing flood fairs and other informative events, together with the organisation of local volunteer flood action groups in vulnerable areas.

4.5 Level of Assessment

Based on the starting level of information available, and with due reference to the SWMP Technical Guidance document, it is proposed to set this study at the **Strategic Level**, meaning that much of the proposed output will be recommendations for additional works or more intense study in defined areas. The aim is, of course to define these areas more precisely.

4.6 Outputs

As part of the SWMP development procedure, and in the process of increasing our understanding of the factors affecting flooding in Derby, the following outputs will be produced:-

1. Develop an easily understandable and straightforward means of recording flooding, including a data entry form suitable for the public.
2. Develop a GIS shapefile, map and database of all Derby surface water and third party assets within the city to be expanded as our knowledge of such assets grows.
3. Enhance the database to enable assessment of any site within the principle urban area with respect to flooding from a variety of sources.
4. Identify a source-pathway-receptor flood risk approach for the city which will indicate clearly the anticipated flood routes.

5. Develop an action plan to identify and reduce flooding in the most affected areas of Derby.

5 Risk Assessment

5.1 Introduction to Risk Assessment Process

5.1.1 Flood Risk Methodology

The risk assessment is based on a source – path – receptor model where:-

- The **source** is the catchment area where the flooding forms, therefore it is important to be aware of the physical features of the area, gradient, permeability, area, furthest distance from the point outfall and, if applicable, soil type. These characteristics define how quickly the catchment will respond to a given rainfall event and are collectively known as the hydrology of the catchment.

- The **path** is the primary route taken from the source to the receptor. Its ability to transfer flow will again depend upon gradient, type of surface the distance travelled and any barriers which may impede the flow (such as fences, walls or buildings). These factors will define how quickly the flood waters descend on a given point and in what quantities.

- The **receptor** is the point (or area) under consideration for a specific flood assessment. This is where the flood waters will collect, and is therefore the point at most risk from inundation from a given storm event. The depth of potential flooding will determine the potential damages and corresponding cost:benefit ratio of an improvement scheme.

5.1.2 Storm duration and Intensity

When considering flood risk the following should be considered:-

- Longer storms generally have a lower rainfall intensity than shorter storms
- The longer the duration, the greater the area that may contribute to discharge at an outfall, thus, the higher the potential discharge. There does, of course come a point where the maximum area is contributing to runoff from the catchment. This is termed the “Time of Concentration”.
- Increasing Urbanisation (paving of surfaces) allows water to flow more quickly across the surface, reducing the time of concentration.
- Shorter more intense storms give rise to flash floods as sewer systems are unable to cope with the influx. Runoff can quickly build up in urban areas as surface water flows over the surface, this is how urban flooding can become severe.

5.1.3 Sources of potential surface water flooding

The following is a list of potential factors which may contribute to flooding:-

- Sheet runoff and overland flows – The increase in development of a previously rural area will dramatically increase the rate and velocity of runoff flows, and will ultimately increase the frequency of overland flows.
- Historic drainage features – As the city has developed many historic drainage features such as ditches and land drains have become lost. When flooding occurs it still tends to follow these historic flow paths.
- Sewer flooding – Much of the city is now urbanised and the channelling of large, and occasionally steep sided paved areas into sewers will result in a dramatic decrease in the time of concentration and a tendency for sewers to flood.
- Watercourse flooding – Although the culverted sections generally have adequate capacity, some open sections may be liable to flood if inlet screens are allowed to block as a result of poor maintenance or fly tipping.

- Gradient change – As river bed gradients slacken, particularly in the south of the city, the capacity of a watercourse channel will reduce and there is a greater tendency for out of bank flow.
- Overtopping of banks – Open sections of watercourse have variable bank heights and may offer different standards of protection against flooding.
- Breach of defences – Some watercourses are protected locally, by shallow earth bunds or brick/concrete walls, if these fail during high flow conditions property inundation may occur.
- Effects of water from main rivers– During (or following) an extreme weather event, the outfall from a minor watercourse into either the Derwent or Trent may be drowned by the rising main river level. If this happens it may result in localised flooding near the outfall. Alternatively the rising levels of the main river may enter the mouth of the minor watercourse and flow back up the line of the brook, emerging from the bank or from culverted sections to produce flooding.

5.2 Fluvial Flood Risk

Flood risk from watercourses tends to lie within areas lining the banks and adjacent low-lying areas. The extent and frequency with which these areas are affected will vary in proportion to the size of the watercourse itself and the anticipated flood flow. If a watercourse has been diverted from its original line, either by development or for the purposes of obtaining a specific hydraulic head, the line of the watercourse may no longer follow the valley floor. In this case, there may be land which is artificially low in relation to the channel and which may be particularly vulnerable to flooding. Additionally, fluvial flows within a channel may be increased if upstream developments are allowed to change the behaviour of the catchment, increasing or accelerating the speed with which runoff enters the system. Much of the following flood risk information is taken from Derby's level 1 SFRA and is based on information available at the time. Figure 5.1, below shows the number and extent of watercourses that lie within the city boundaries, together with their current status.

5.2.1 Main Rivers

These are watercourses which are maintained by the EA, either by means of direct labour, or by the city council under license.
Whilst Derby is not the administering authority for main watercourses, as a Lead Local Flood Authority we have a duty to consider flooding from all sources. Many of these watercourses are now culverted and the clearing of trash screens due to fly tipping, or the transportation of vegetation, can become a major task at certain times of the year. Additionally, the condition of culverts must remain a matter of concern as access for the purposes of replacement can be difficult or expensive, particularly in the highly urbanised environment of a densely populated city. The following are descriptions of the relevant watercourses with identified or known risk areas, the descriptions have been generally abstracted from Derby's level 1 SFRA.

5.2.1.1 The River Derwent

This runs through the centre of Derby in a southeasterly direction and has a primary catchment which covers over 1200km^2. It consists of the whole of the upper Derwent valley, tributary valleys and moorland at the upper reaches of the respective rivers. There are three reservoirs and associated dams near the head of the river, these are the Howden, Derwent and Ladybower reservoirs and together they act as attenuation for the upper reaches of the catchment. The river runs through a steep sided valley with little available floodplain space, and falls some 125m from the Ladybower reservoir 50km upstream of Derby. For this reason it is highly reactive and will frequently reach peak flows very rapidly following a major rainfall event. As it reaches the Derby area, the derwent valley opens out and becomes quite flat, with broad banks. The following historical events show the importance of the R. Derwent to the welfare of the city.

1931/32, much city centre flooding occurred, predominantly along the River Derwent and the Markeaton Brook corridors.

1965, the R. Derwent flooded the Little Chester area resulting in the flooding of some 700 properties. Following this the river defences were improved.

The Derwent was modelled by Black and Veatch in 2006 on behalf of the Environment Agency. This report was later reviewed and summarised in Derby's level1 SFRA of 2009. Derby has a number of existing river defences which provide a varying Standard of Protection. The residual flood risk to the city results from one of two modes of failure, namely those of overtopping or breach of defence.

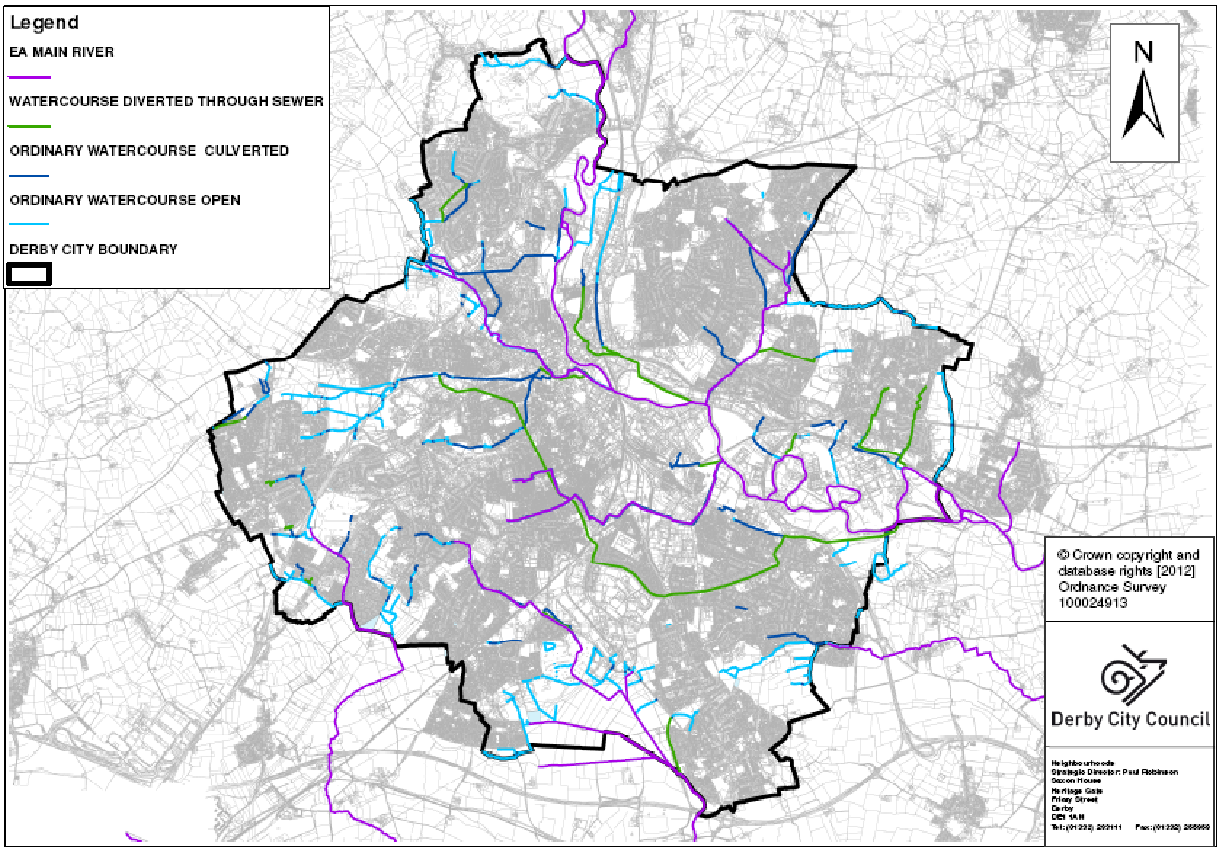

Figure 5.1 – Watercourse Map showing Derby City Extents

Overtopping - The risk of a river defence being overtopped will depend on the height of the defence in question and the relative height of the river flow. The associated risk of flooding to development (whether existing or proposed) will depend upon the topography of the land behind the defence, the vulnerability of the development and the distance travelled by flood waters (e.g. the longer the flow path, the slower the flow and the lower the leading edge of the wave).
Table 5.1 shows the estimated risks of overtopping of existing river defences on the Derwent.

Table 5.1 - Estimated overtopping flood risk from the River Derwent

Location	Flood Risk Description
A38 to Darley Abbey	River flows are channelled under the A38 bridge (GR435866, 339942) and then spread onto washlands on either side. Existing defences on the east bank are intermittent and poorly maintained and water is able to flow “out of bank” for approximately 2km, bypassing the Darley Abbey weir and flooding sports fields before re-entering at Chester Green. Flooding in this area is mainly nuisance.
Darley Abbey to Elvaston	Left bank – Extensive flooding for events in excess of 1%, with residential areas in Little Chester, Chester Green and the lower areas of Chaddesden primarily at risk. Right Bank – o River Street, Handyside Street, St. Marys Court, Bath Street and Duke Street (residential); o Downstream of St. Mary’s Bridge including Sowter Road and the areas to the east of Full Street (non-residential); o City centre including the Council House, Corn Market, Albert Street, Moorledge and the Cockpitt areas including limited areas of Traffic Street and the Eagle Centre (non residential); o Pride Park (non residential); o Alvaston area between the River Derwent, London Road and Raynesway; o Areas to the south of the Alvaston Bypass around St. John Fisher school between the bypass and Alvaston Street Overall on the right hand side, approximately 500 residential properties and a large number of non-residential properties are at risk for a 1% event.

Breach – The effects of breach failure are such that the initial water depth and velocity will be high but will reduce as distance from the breach increases. The risk of flooding, caused by the breach of existing river defences, is defined by, and is directly proportional to the height of the defence, the physical structure, its condition, the length of time that water levels will remain high and the time required to effect a suitable repair.
Table 5.2 shows the estimated risks of breach failure of the defences.

Table 5.2 - Areas potentially affected by breach failure of defences

Left (East) Bank	Right (West) Bank
Residential and commercial properties in Darley Abbey	Residential properties in Duke Street
Alfreton Road industrial estates	Residential properties between Full Street & the River Derwent
Residential and commercial properties off Old Chester Road, City Road and Etruria Gardens	Commercial properties close to river defences in Pride Park
Industrial sites Raynesway and Spondon	Industrial/Commercial sites off Raynesway

5.2.1.2 Markeaton Brook

This is the largest and most important of the minor watercourses in Derby, it rises close to Hulland Ward (426440, 346800) as the Black Brook and flows generally south to southeast, changing its name several times, and finally entering the city via the grounds of Kedleston Hall and Markeaton Lane. Just inside the city boundary it is joined by the Mackworth Brook and is recorded as Main River from this point. It then flows through the city in a mixture of culvert and open sections, before discharging into Mill Fleam on the southeast of the city centre. At the junction of the Wardwick and Victoria Street is is joined by the combined flow from the Littleover and Bramble Brooks. Markeaton Brook has a total catchment of some 50km^2 located generally to the northwest of Derby and a response time, to peak flow, at its confluence with the Mackworth Brook, of around 13 hours.

Following a number of recurring flood events,the Northern Flood Relief Culvert (NFRC) was commenced in 1937 and collects peak storm flows at Markeaton Lane, diverting them into the R. Derwent at Darley Park. The inlet structure was upgraded in 2005/6 to improve efficiency and the level of protection offered. Currently the brook is considered to offer a minor threat to the city provided the NFRC operates successfully, however in the event of a total failure of the NFRC there exists a significant risk of flooding through the city centre.

The remaining Markeaton Brook is prone to flooding as a result of the following:-

- In places the brook course is narrow and overgrown (mainly due to neglect by riparian owners), reducing capacity and increasing the potential for flooding under extreme events.
- Vandalism and fly tipping are prevalent along the open stretches, resulting in reduced capacity.

Table 5.3 - Potential problems for a 1% event (Markeaton Brook)

Location	Grid Ref.	Description
Watson Street & Tivoli Gardens	434180, 337178	The brook course is heavily overgrown and has a capacity of approx. 9 cumec. 10 No. properties recorded garden flooding in Watson Street (2001).
Eaton Court, Mundy Street and Leaper	434236, 336803	There are a number of changes of direction in this area and the brook may become choked with debris at times.
Bridge Street & St. Johns Terrace	434552, 336632	Riparian owners have created garden terraces, thus reducing brook capacity. This has caused historical flooding for low-lying properties.
Brook Street to Agard Street	434745, 336578	A high number of riverside trees and an enclosed environment results in a high risk of blockage. The culvert inlet above Ford Street may become blocked.
Ford Street, Stafford Street, Curzon Street, Bold Lane, Jury Street and Willow Row	434933, 336510 (Approx.)	This section is culverted beneath city centre streets. Generally low lying area, may become inundated if the Markeaton Brook becomes blocked downstream
Saddlergate, Corn Market, The Strand, Victoria Street, Albert Street, Moorledge, Cockpitt	435086, 336280	This are is generally low-lying compared to the adjacent R. Derwent and Markeaton Brook. If the brook outlet becomes drowned at Mill Fleam this area may flood via surface water drains.

5.2.1.3 Hell Brook

This brook rises in the centre of Mickleover (GR431368, 334788) and crosses into Littleover, near the bottom of Pastures Hill. The upper part of the brook is entirely urbanised within an extensively residential development and is fed by a number of surface water sewers. It is main river from the point at which it crosses under the A38 and flows south to the city boundary, then follows the boundary round to the back of the Sunnyhill area before then bearing south again towards the River Trent, crossing the Trent and Mersey Canal at Findern. With the exception of some road crossings, the Hell Brook is open throughout its length. The upper reaches of the watercourse are steeply sloping and extensively urbanised, but slacken below Heatherton, resulting in an area where the banks are prone to overtopping and ground is heavily waterlogged. Planned developments, particularly at the extreme southern end of Stenson Road could have a pronounced effect on the behaviour of the brook and it is critical that drainage strategies in such areas are managed correctly.

The brook has been extensively modelled on behalf of the Environment Agency by JBA consulting, with additional modelling by Derby to investigate contributing sewer networks, results indicate that recent drainage infrastructure is designed on a 20% AEP event as the worst case scenario, so that an element of flooding is to be expected for a 1% AEP event.

Table 5.4 - Potential problem areas for a 1% event (Hell Brook)

Location	Grid Ref.	Description
Bradwell Close	431443, 334379	This has a 5000m^3 volume area with a 450mm downstream orifice and a 525mm discharge pipe. There are concerns that this may flood under extreme circumstances.
Brierfield Way & Kipling Drive	431150, 333868	Modelling results indicate that 2000m^3 may accumulate here at certain times. There is currently no indication as to whether this area will accommodate the flows, however this has the potential to flood surrounding residential infrastructure.
Cattleshaw Drive	431439, 333013	This point is the confluence between two tributaries of the Hell Brook and serves the local infrastructure in terms of storm water disposal. In addition there is a large mixed development planned for the fields to the south which may be a source of occasional flooding.
Pastures Hill	431890, 333415	There is a large trash screen in this area which protects a highway culvert, this collects a large amount of debris and requires regular maintenance. If allowed to block this could result inundation of Pastures Hill and low-lying residential areas to the southwest.
Junction of Rykneld Road & Hollybrook Way	431517, 332926	Possible flooding from a build-up of debris and the discharge of local storm sewers.
N of Moorway Lane/ Brookdale Drive	432180, 332325	Flood Zone 3, prone to regular flooding.
SE of Moorway Lane	432452, 332087	Flood Zone 3, noted as flood plain for Hell Brook extensive flooding for events up to, and including 1%.

5.2.1.4 Cuttle Brook

This rises in the middle of Littleover (GR 432670, 333822) and flows southeast through Sinfin Moor and the rear of Chellaston before flowing into the R. Trent at Swarkestone. It rises in The Hollow/Carlisle Avenue area and flows a short distance east before being enmained downstream of Rabown Avenue. It runs for some distance as an open watercourse, before entering a culvert at the eastern end of Stenson Road, whereupon it is culverted until it reaches the middle of Sinfin golf course. Thereafter it is open until it joins the R. Trent. The upper reaches of the Cuttle Brook are characterised by a heavily urbanised residential development, with a number of storm sewer systems flowing directly into the brook. Many of the housing estates contributing to the flow in the brook are old and discharge directly to the brook without attenuation or control. The brook has been previously been modelled on behalf of the Environment Agency by JBA consulting. As with the Hell Brook, it seems that estate drainage is based on a 20% AEP event as worst case, thus resulting in flooding from a 1% AEP event.

Table 5.5 - Potential problem areas for a 1% event (Cuttle Brook)

Location	Grid Ref	Description
The Hollow & Carlisle Avenue	433045, 333450	This brook rises near to The Hollow in Mickleover, and receives storm water input from the immediate area.
Downstream of Brooklands Drive	433330, 333710	Flooding from the brook may affect properties in Taverners Crescent and Willson Avenue as a result of riparian owners encroaching of the banks of the brook.
Rosamunds Ride	433873, 333604	Brook capacity is significantly less than anticipated flows, therefore surcharging regularly occurs.
Sunnydale Park	433895, 333327	A balancing area and throttle pipe has been installed by STW, this will allegedly accommodate 20000m^3 of storage equivalent to a 20% AEP event. For more severe events the area will surcharge causing flooding to local development and restricting upstream flows.
Residential areas off Wellesley Avenue	434039, 332999	Various locations, small diameter sewers and flat topography seems likely to result in frequent flooding with up to 15 residential properties at risk from a 1% AEP event. Cuttle Brook is thought to have greater capacity than either the sewers or the culvert.
Kendon Avenue & Stenson Avenue	434282, 332886	At risk of flooding if the if the screen on the culvert entrance on Kendon Avenue becomes blocked.
Sinfin Lane, Thackeray Street, Wilmore Road & Rolls Royce site	435001, 332531	The culverted brook appears to have insufficient capacity for a 1% AEP event and significant flooding of low-lying areas is possible.
Sinfin Moor	435541, 332122	Much of the area lies in F.Z.3 and acts as a storage area for the R. Trent and Cuttle Brook. Additionally, as the topography slackens, the velocity of water in the channel will slow, decreasing its available capacity.
General	Various	In total, in excess of 200 properties may be at risk of flooding from the Brook directly, with a further 300+ from surface water sewers.

5.2.1.5 Chaddesden Brook

This is the combination of two lesser watercourses, the Lees Brook which rises in Locko Park, and Wood Brook which rises in Oakwood. Chaddesen Brook is main river from the confluence, at the Lees Brook Community College, and flows south through the east side of Chaddesden to the River Derwent, it is open for the most part, but is culverted just to the north of the A52. This is one of the largest brook systems in Derby in terms of flow volumes, brook dimensions and catchments, the two contributing catchments exhibit distinct features of opposing rural and urban runoff features. To date, the Chaddesden Brook system has been modelled solely using the WinDes sewer design package with dedicated channel sections in place of open channels. It is unclear precisely how much of the piped wood brook drainage has been included, or how the rural sections of Lees Brook have been modelled.

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Table 5.6 - Potential problem areas for a 1% event (Chaddesden Brook)

Location	Grid Ref.	Description
Lees Brook Community College to Maine Drive	438405, 337210	Properties adjacent to the brook course are vulnerable as a result of excessive flows.
Chaddesden Park	438374, 336963	Low lying areas within the park are liable to flood in accordance with local topography and former usage.
Autumn Grove/ Meadow Lane	437878, 336202	Properties between Autumn Grove/ Meadow Lane and the A52
General	Various	Approx. 80 residential properties are considered to be at risk from flooding.

5.2.1.6 Cotton Brook

This is a wholly culverted watercourse which arises as the combination of two old tributaries (both of which now identified as the Cotton Brook), the confluence of which occurs at the junction of Pear Tree Road and Dairy House Road. The principal catchments are the heavily urbanised areas of Normanton and Pear Tree, however the there are rumoured to be several older tributaries whose routes can no longer be traced but which may cause problems if the aging culverts start to collapse through lack of maintenance. Sewer inflows to the brook consist of a mixture of residential and highway drainage, however there are a number of combined sewer overflows (CSO's). The Cotton Brook typically has an invert of around 2.0m and consequently has very little cover, and so is at risk of flooding under certain conditions. The primary concern is the age and condition of the existing culvert, together with the density, and sensitivity of surrounding development. Much of the culvert is condition grade 4 or 5 and lies directly under Normanton Road. We understand that the EA are currently planning to have this watercourse modelled, however CCTV surveys show that the status and condition of many of the culverted sections are very poor and may require improvement very soon.

Table 5.7 - Potential problem areas for a 1% event (Cotton Brook)

Location	Grid Ref.	Description
Warwick Avenue/ Stenson Road	434549, 333960	Estimated 500m^3 of flooding liable at the above junction
Shaftsbury Street (Sth)	435873, 333950	Approximately 22m^3 of flooding within the industrial estate.
Pear Tree Road	435150, 334650	Culvert located beneath busy urban street. Condition 5, critical risk from collapse

5.2.1.7 Thulston Brook

This rises near to Shelton Lock and flows east towards Elvaston and Thulston, ultimately discharging to the R. Derwent at Church Wilne. It has a very shallow gradient, falling only 4m over a distance of 2.5km and holds water over much of its length. In addition, a lack of routine bed maintenance by riparian owners, over a period of time, has resulted in siltation and subsequent reduction in available depth between the end of a culvert at

Thorness Close and the A6 Elvaston bypass. Thulston Brook is open over most of its length and flows out of the city into largely rural downstream catchments, this has the effect of reducing and slowing the inflow from such areas, allowing the initial surge from urban areas to pass quickly downstream, but creating a long lag time to the flow. It is regarded as Main River from the Thorness Close culvert outfall.

Table 5.8 - Potential problem areas for a 1% event (Thulston Brook)

Location	Grid Ref.	Description
Calvin Close, Border Crescent	438433, 332198	Small propensity for flooding (circa 200m^3) mainly affecting low-lying properties.
Field Lane	438686, 332040	Small potential volume of flooding (approx. 230m^3) mainly affecting low-lying properties.

5.2.2 Minor watercourses

These are administered directly by Derby and are owned jointly by the riparian owners' whose land abuts or encloses them. These include the following:-

5.2.2.1 Littleover Brook

This rises as a sewer network serving the upper part of Littleover in the vicinity of the Chain Lane/ Corden Avenue junction and Uttoxeter Road west of the Derby City General Hospital. It also collects storm flows from the hospital development itself and some commercial areas immediately adjacent before discharging under the A5111 Manor Road and continuing down through the lower part of Littleover. The catchment is heavily urbanised throughout, and much of the brook course is either culverted or strictly channelised to Curzon Street where it meets the Bramble Brook. The combined Bramble Littleover is then bifurcated and half flows along Curzon Street, while the remainder flows along Newland Street joining the Markeaton Brook under The Wardwick. The Littleover Brook is prone to flooding due to the presence of highway culverts with insufficient capacity, the blocking of screens by fly tipping and/or the build up of vegetation and the lack of adequate maintenance by riparian owners. The brook was modelled by URS in 2010/11on behalf of Derby and it is proposed to undertake improvement works in the near future.

Table 5.9 - Potential problem areas for a 1% event (Littleover Brook)

Location	Grid Ref.	Description
Manor Road Culvert	433159, 335150	Existing culvert is under-sized and cannot support the projected flows. Estimated 500m^3 of flooding with up to 15 residential properties at risk. Upper catchment has very short response time.
St. Cuthberts Road, St. Wystans Road, St. Albans Road, St. Davids Close	433317, 335180 to 433633, 335140	3 No. highway culverts which are incapable of taking 1% flows due to the presence of services and intake screens which are prone to blocking. Up to 400m^3 of flooding possible, resulting in inundation of properties.
Bramfield Avenue (Dean Street allotments)	434225, 335105	Open section of brook with a slackening gradient and overgrown banks. D/s screen is prone to blocking resulting in flooding of allotments and possibly adjacent gardens. Potential for property flooding is limited.

Location	Grid Ref.	Description
Woods Lane and Boyer Street	434561, 335313 to 434739, 335419	Brook is highly channelised with high walls and fences both sides. In addition, sections have been inappropriately culverted resulting in reduced capacity. Up to 600m^3 of flooding is anticipated with flooding to properties.
Outfall	434867, 336186	The confluences, first with the Bramble Brook and then the Markeaton Brook, may result in problems under 1% AEP conditions.

5.2.2.2 Bramble Brook

This rises in the centre of Mickleover, taking surface water sewer flows from the local residential development around Devonshire Drive and flowing east towards the city. There are several lesser tributaries which accept flows from the northern part of Mickleover, rural land to the north, and the former railway line between Mickleover and Mackworth. It crosses the A38 at the Kingsway roundabout then flows east through various commercial development sites parallel with Slack Lane and Great Northern Road then onto Curzon Street where it joins the Littleover Brook. The head of the system has been extensively developed and primarily conveys surface water from the estate as an open watercourse. Where it enters a culvert, around 50% of flows are diverted into a 1200mm dia. STW sewer, the remainder flowing through the city, almost entirely in culvert, taking a series of surface water inflows with some additional Combined Sewer Overflows. The main Bramble Brook culvert is very old in places and major works may be required to prevent collapse. The Bramble Brook was modelled by Atkins in 2010/11, on behalf of Derby and future improvement works are planned**.**

Table 5.10 - Potential problem areas for a 1% event (Bramble Brook)

Location	Grid Ref.	Description
West of A38	432686, 336065	Size and gradient of channel may result in up to 700m^3 of flooding. The location of the brook will result in this being more nuisance than risk to property.
A38 Kingsway Roundabout	432831, 336116	Up to 5000m^3 of flooding is estimated to occur in the area of the roundabout, and the industrial estate downstream.
Cheviot Street Park	433415, 336192	This area is prone to fly tipping and may pose a threat to downstream properties, if allowed to flood.
Various areas	Various	Numerous small flooding areas
Outfall	435145, 336183	If the Markeaton Brook is in full flow the outfall from the combined Littleover/Bramble Brook may become drowned resulting in the system backing up.

5.2.2.3 Wood Brook

This rises at the southeastern corner of a park, off Bishops Drive, and flows southeast at the rear of properties fronting onto Wood Road, bearing south to keep a general alignment with Wood Road. It is culverted for all but its first 100m or so and accepts storm flows from throughout the Oakwood area. Wood Brook joins with Lees Brook to form the Chaddesden Brook just to the south of Morley Road. In the last three decades or so, the catchment characteristics have changed from pasture and arable land to intense residential. No sustainable drainage features or balancing features have been included, and the catchment now responds to rainfall with unprecedented speed towards the watercourse.

Table 5.11 - Potential problem areas for a 1% event (Wood Brook)

Location	Grid Ref.	Description
Bishop's Drive, Springwood Drive	438217, 338501	Risk of flooding from storm sewers.
Saundersfoot Way, Tredegar Close	438849, 338807	Risk of flooding from storm sewers
Kirkstead Close	438781, 338057	Flooding along route of old watercourses & overland flows.
Morley Road	438890, 338097	Risk of flooding from highway drainage and highway culverts.

5.2.2.4 Lees Brook

This rises in Locko Park (GR441141, 339118), to the north of Spondon and flows southwest towards the southern edge of Oakwood. It is the focus of an extensive rural catchment and is fed directly from The Lake, a prominent feature of the park. It is joined by a tributary from the northern edge of Spondon as it crosses Locko Road, then turns due west towards the Lees Brook Community College where it is joined by the Wood Brook forming the head of the Chaddesden Brook. In itself the Lees Brook may well be prone to flooding, however it is situated in a defined rural valley with little development within the affected zone.

5.2.2.5 Amber Brook

This brook system drains much of the Allestree area, officially rising at GR 434044, 339173, before discharging into the Markeaton Brook. The catchment is steep resulting in high flows and minimal storage. There is an additional historical tributary entering from the Blenheim Drive in the north. Following intensive development in the 1960's, there was a series of flooding events, eventually resulting in the diversion of this tributary into a dedicated storm sewer beneath Allestree Lane and the culverting of much of the remaining brook.

Notable features include:-

- open sections are narrow in places and have little freeboard
- much of the culverted section has insufficient capacity to cope with 1% flows resulting in the potential for flooding to highway and valley bottom over the old channel route
- principal area lie between Fairway Crescent and Allestree Lane to the east of Kedleston Road.

5.2.2.6 Dam and Boosemoor Brooks

These currently lie mainly outside the city boundary in the Breadsall area, but flow under Haslams Lane and discharge into the R. Derwent opposite Darley Park, attention may be required at a later date.

5.3 Pluvial Flood Risk

In an urban environment, pluvial or rainfall-based flooding is inevitable at some time, any large paved area will result in an increased rate of runoff, times of concentration will be significantly reduced and water will tend to flow quickly, often bypassing poorly located gullies or drainage channels. The route that this surface water takes, and how it is intercepted, will determine whether or not this flow affects vulnerable areas, and to what extent. This situation may worsen if the sewers become inundated by sudden flows and flood above ground level.

5.3.1 Historical Flood Data

Historic flood events for Derby have been recorded dating back to the 1600's, most of these relate to Fluvial flooding from the R. Derwent or Markeaton Brook, however there are a number of recent events in which Pluvial effects seem to be the trigger.

9 July 1981, an intense rainfall event resulted in some 80mm of rainfall in 70-80 minutes, gullies and drainage systems alike were inundated and a significant number of properties, both residential and commercial were flooded.

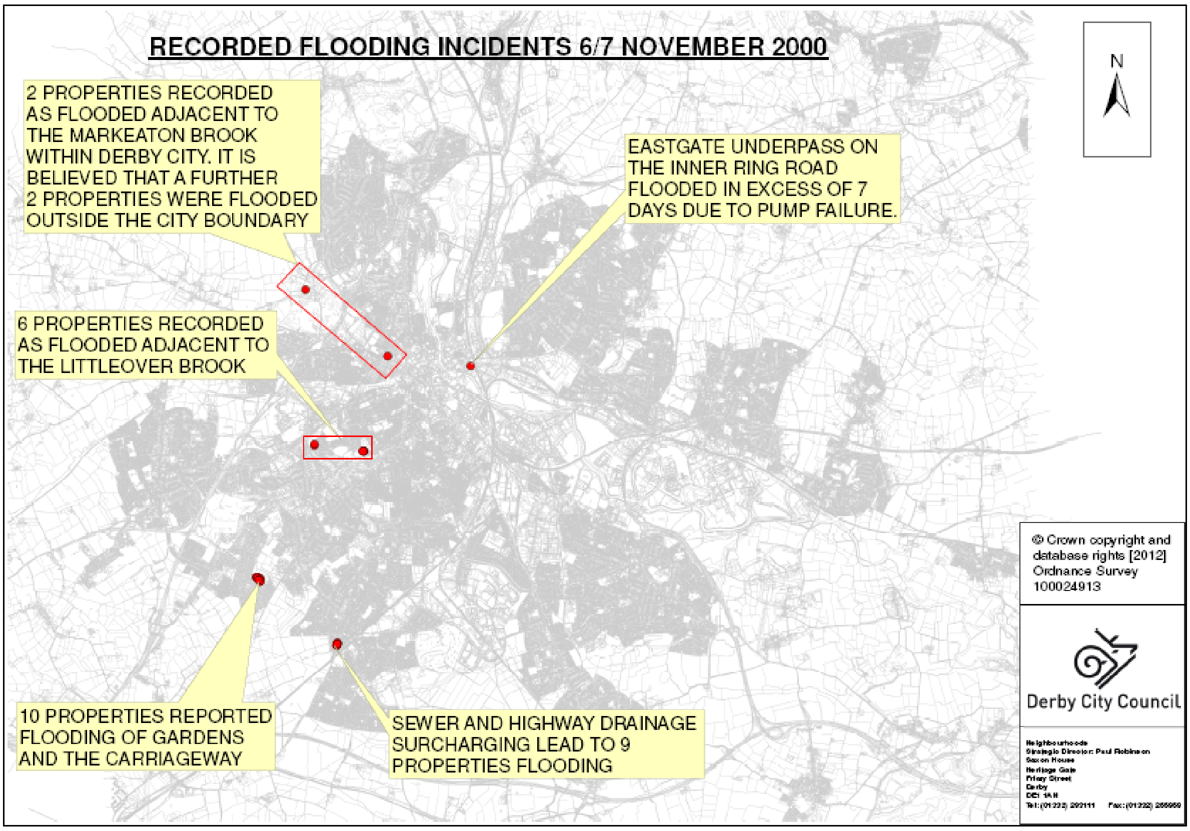

Figure 5.2 Historic Flood Events November 2000

5 November 2000, a prolonged period of rainfall culminated in an intense storm which resulted in major flooding of the R. Derwent, Markeaton and Bramble Brooks, together with pluvial flooding of various parts of the city centre. The NFRC and Bramble Brook Culvert diverted the worst of the flooding from the north of the city but the Eastgate underpass was severely flooded and closed for several days. Although much of the flooding was fluvial, the final event was a combination of both sources.

7 July 2001, a heavy storm falling on the southwest of the city resulted in sewer and surface flooding in Taverners Crescent and Stenson Road areas

30 July 2002, some 40 separate reports were received following a prolonged period of heavy rain.

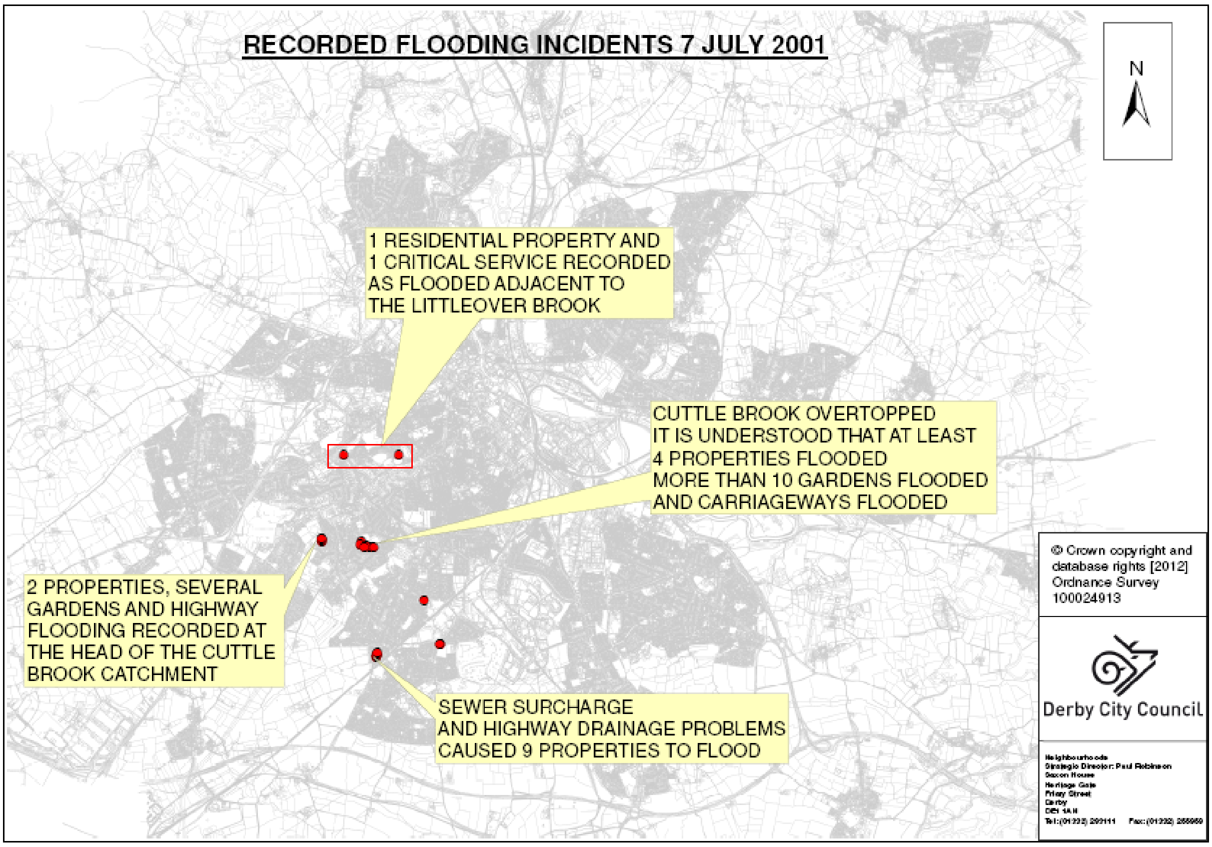

Figure 5.3 Dispersal of flood records July 2002

5.3.2 Published Flood Data

GIS databases provided by the EA show in very basic form how rainfall is likely to behave for critical events. The first of these, "Areas Susceptible to Surface Water Flooding" (AStSWF), was initially created to show the effects of a 0.5% (200 year) AEP event (also defined as a 100 year plus climate change) and a 6.5 hour storm event. However, the data makes no allowance for the presence of sewers or buildings, considers no losses due to infiltration or transpiration and is somewhat vague in its assessment of depth. It is, however, useful for determining the likelihood of flood extents under a fully wetted condition.

Figures 5.4 and 5.5 show the numbers of properties at risk from flooding in the "Intermediate" and "More" depth ranges. The contributing figures within the colour bands have been determined arbitrarily, however in each case they are balanced to show a reasonable spread of "At Risk" properties.

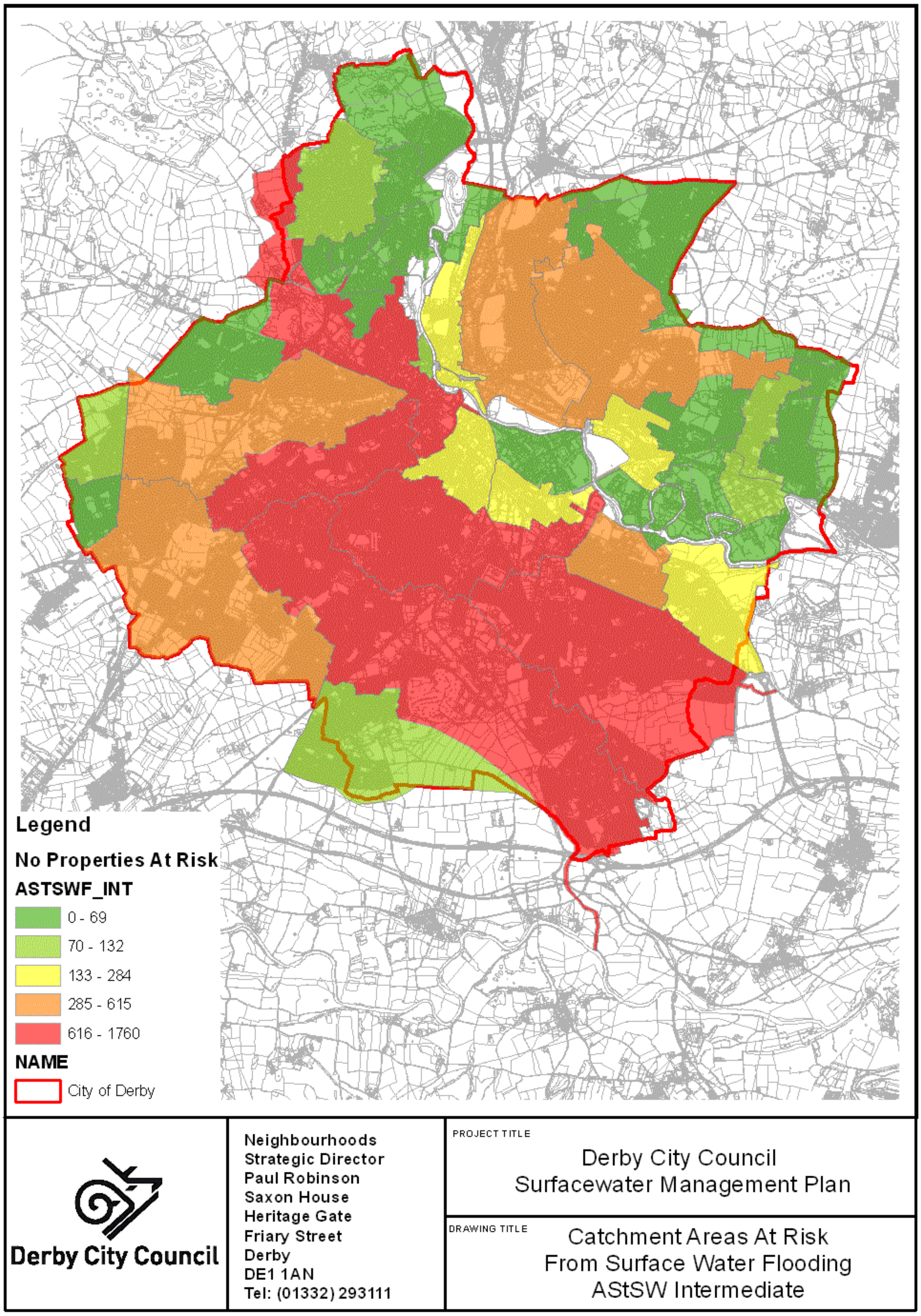

Figure 5.4 No of properties at risk (AStSWF Intermediate)

The areas shown most at risk under these conditions are the Cuttle, Thulston, Cotton, Littleover and Markeaton Brooks.

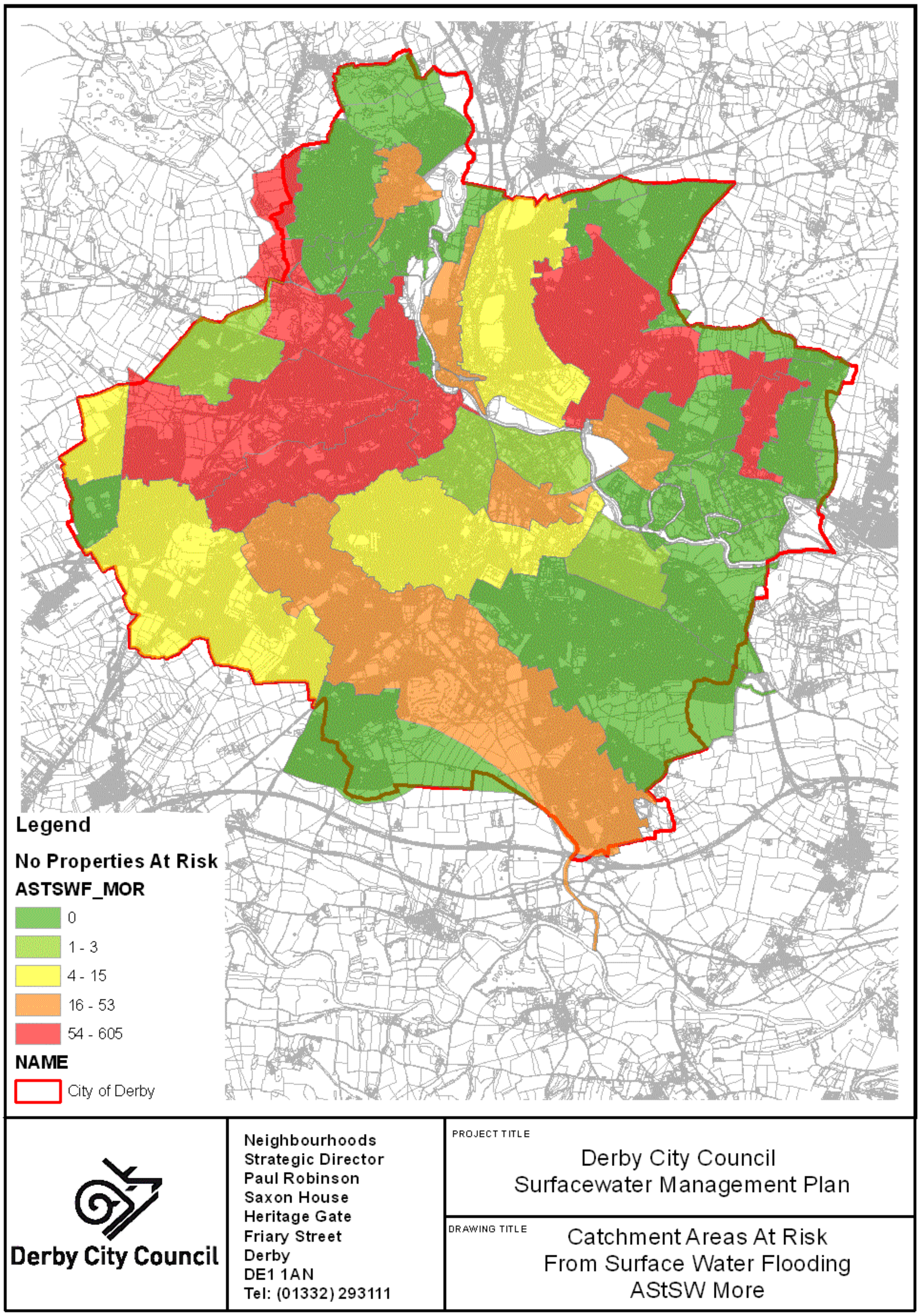

Figure 5.5 No of properties at risk (AStSWF More)

Here the areas shown most at risk are the Bramble, Littleover Markeaton and Chaddesden Brooks, together with the little known Willowcroft Brook which was adopted by STW some years ago, but still remains as a highway flood route under extreme conditions.

The more recent, "Flood Maps for Surface Water" (FMfSW) considers not only the 0.5% event but also a lesser 3.33% (30 year) storm, and reduces the duration to 1.1 hours, giving a more intense rainfall event. It also considers two nominal depth zones of up to 0.1m (shallow) and up to 0.3m (deep), although the shallow dataset is considered to be not quite deep enough to inundate a residential property and the 30 year (3.33%) event is not considered of sufficient severity, thus 0.5% deep is considered in exclusion.

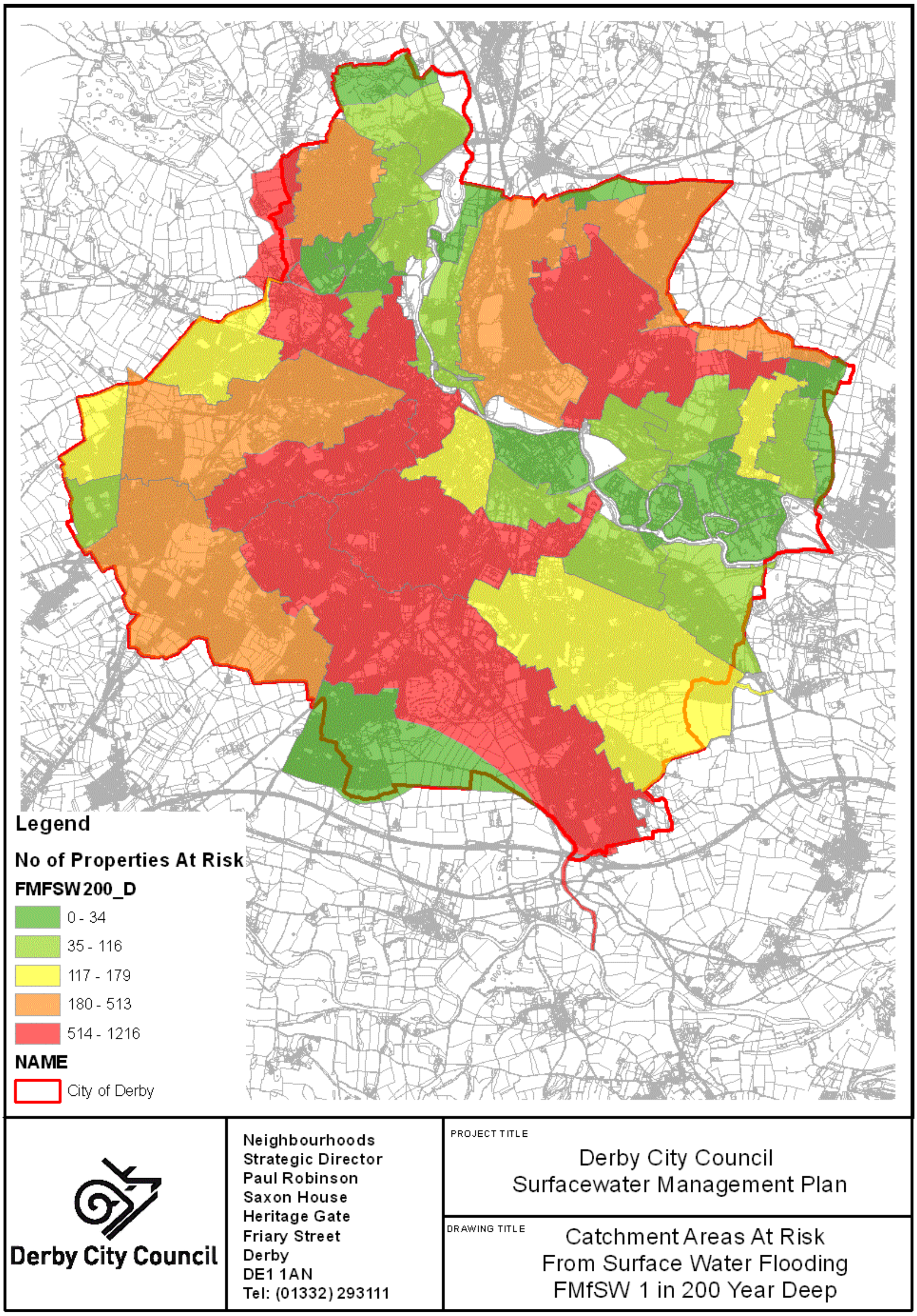

Figure 5.6 No of properties at risk (FMfSW deep)

Here, the Cuttle, Cotton, Markeaton, Chaddesden, and Littleover Brooks are at highest risk, while the Hell, Bramble and Lees Brooks remain at moderate risk. The Thulston Brook does not appear to be vulnerable to deep flooding from 200 the year event.

The FMfSW dataset also includes for the presence of buildings on a 5m grid, allows for the effects of sewers and infiltration losses in the form of rural and urban environments, and gives defined depth bands. This database is generally given to be the more appropriate of the two when looking at more normal rainfall events and shows with reasonable accuracy the anticipated surface water flow paths under these conditions. By comparison, the AStSWF dataset which does not allow for losses may be considered to deal with the wet condition, where a critical storm occurs after a prolonged period of rainfall, and normal systems are unable to cope, naturally, surface runoff will be greater. The depth classifications for AStSWF are not defined like the FMfSW data and it is more difficult to assess the precise threat offered at each predicted flood level. The following table shows the assigned bandwidths of at risk properties related to each of the datasets used for pluvial flooding, together with the respective colour bands used to illustrate the risk level. Bandwidths are arbitrary, but have been spaced to give as reasonable a spread of properties as possible. The bands are coloured from dark green to red with increasing severity of flooding potential and this colour scheme has been applied to the brook catchments to illustrate the risk potential of each event.

Table 5.12 Properties at risk of flooding (numbers)

Threat Range	FMfSW (200 yr)	AStSWF	
	0.3	Int	More
Dark Green	0-34	0-69	00
Light Green	35-116	70-132	1-3
Yellow	117-179	133-284	4-15
Orange	180-513	285-615	16-53
Red	514-1760	616-1760	54-605

Since all of the most vulnerable watercourses are culverted to a greater or lesser extent, it is essential that the culverts are maintained and regularly inspected, and that inlet screens and open sections are inspected to ensure a high level of maintenance.

5.4 Severn Trent Sewer Network

Like all urban settlements, Derby has an extensive network of storm, foul and combined sewers, most of these are adopted and lie directly under the control of Severn Trent Water.

In October 2011, the remainder of currently private sewer connections, serving more than one property, also came under the jurisdiction of STW following the implementation of amendments to section 105 of the Water Industry Act (1991) and as introduced by the Water Act (2003). The relevant changes and transfers will be effected by the Water Industry (Schemes for the Adoption of Private Sewers) Regulations 2011.

Currently, however, not all private sewer connections have been adopted by the water companies, items such as private pumping stations and connections to watercourses remain private. For details of all relevant changes, readers should access the DEFRA website at:-

http://www.defra.gov.uk/environment/quality/water/sewage/sewers/

STW are currently in the process of reviewing their existing sewer model for Derby which will hopefully allow a greater understanding of the likely performance of adopted sewers serving the city. It is expected, that under the partnership between Derby and STW, the results of this modelling exercise will be made available to Derby City Council subject to the signing of a suitable confidentiality agreement.

It is known that a number of minor watercourses within the city have, over time, been connected into the adopted sewer network, and have thus been lost as land drainage assets. In addition there are a number of CSO outfalls which discharge into watercourses during extreme events.

5.5 Highway Drainage

Derby became the Highway Authority for Derby in 1997, assuming responsibility from Derbyshire County Council, at this time we inherited very little recorded detail of the highway drainage network. In 2009, in order to improve our knowledge and allow efficient management of the system Derby entered into a partnership with Nottingham City and Leicester City Councils, under the “Three Cities Alliance” to obtain funding from the Department for Transport in order to trace and record our joint highway drainage assets, a total of £233k was awarded for this purpose.

Currently, two methods of approach are being used for the data collection, the carrier drain network is being identified using a combination of old sewer records and manual tracing, while gullies are being located using a Global Positioning System (GPS) which provides co-ordinates and a level on the gully cover. The identification of the drain network requires a good knowledge of both drainage legislation and drainage history to enable correct determination the legal status of the relevant pipes.

Figures 5.7 and 5.8 indicate the extent of the highway drainage network located as of 9.12.2010.

5.5.1 The Function of Highway Drainage Network

The primary function of highway drainage is to collect surface water from the highway and discharge it, to either a public sewer or a watercourse. In practice, however, the highway often receives water from adjacent property in the form of runoff from drives and, during periods of extended rainfall, (when the surrounding soils become saturated) from garden and other greenfield areas. As such, therefore, the highway drainage network can have a large impact on the surface water flood risk of a given area.

5.5.2 Types of Highway Drainage Systems

In Derby, the majority of the highway drainage takes the form of gullies situated in the channel of the carriageway and connected via a connection pipe, directly to a sewer, or watercourse, or via a carrier drain to a sewer or watercourse. Other forms of highway drainage do exist, however these account for a very small proportion of network. They include linear kerb drainage systems (used recently for the new Derby Inner Ring Road), and highway ditch systems which still exist on some of the old highways towards the City boundary.

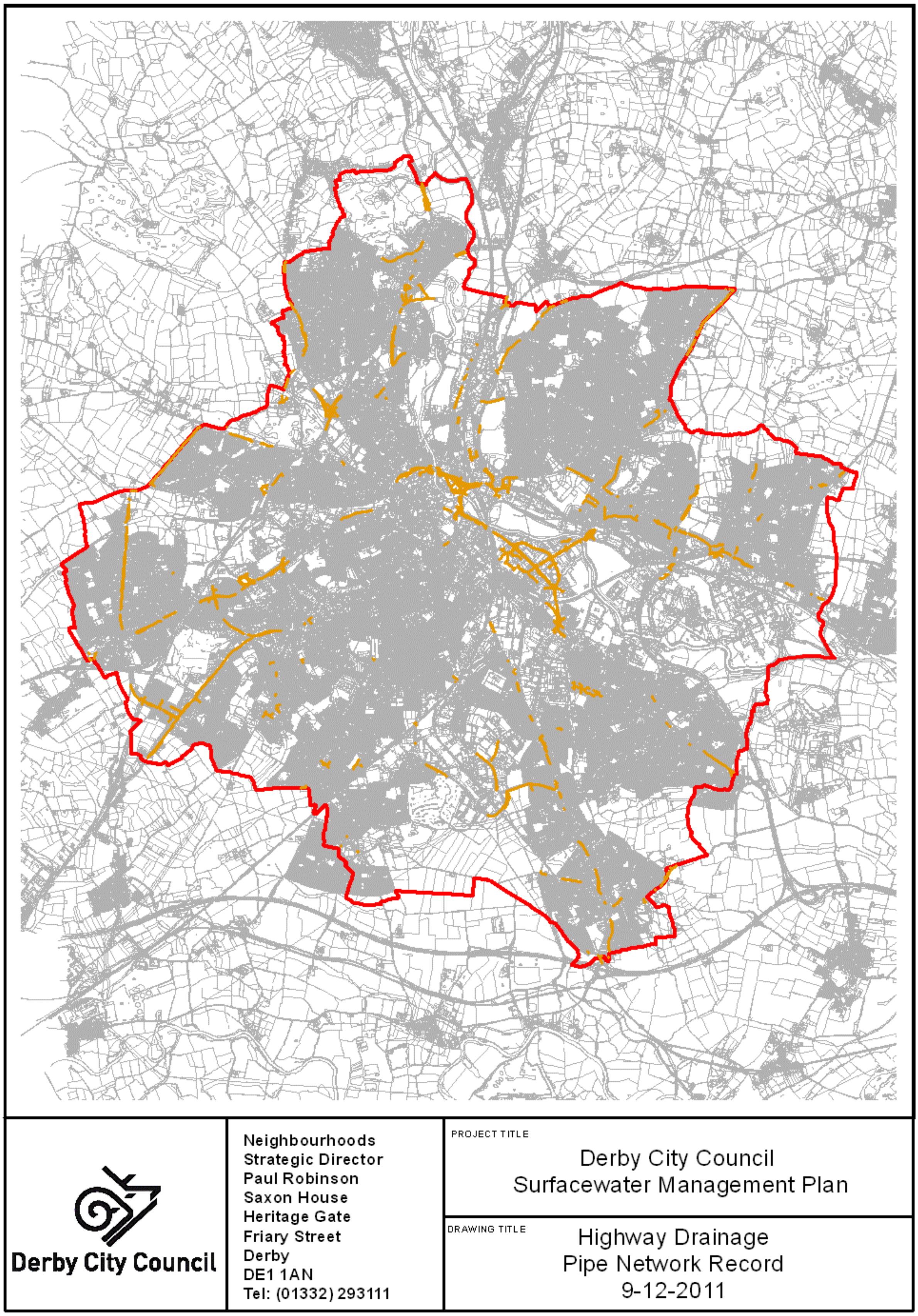

Figure 5.7 Highway Drainage Pipe Network

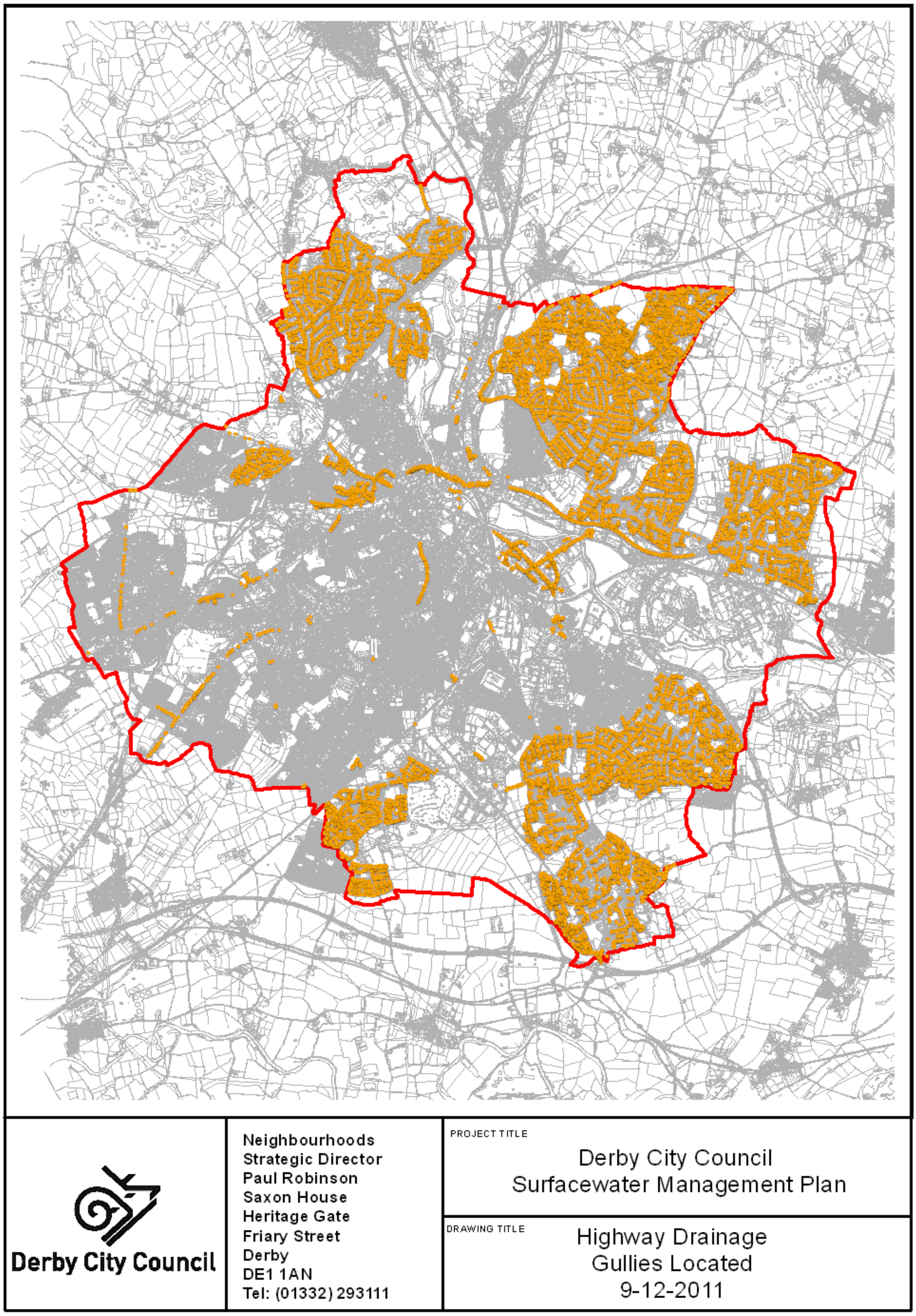

Figure 5.8 Map of located gullies to date

5.5.3 Highway Drainage Capacity

In order to understand the critical features that affect highway drainage capacity it is best to consider how flooding could occur using the source path receptor methodology. This will be done for the normal gully type of highway drainage as this is the most prevalent in the city.

<u>Source</u>
In terms of highway drainage, the source is heavy rain falling onto the footways and carriageways. During periods of prolonged rain, driveway and surrounding green areas may also contribute

<u>Pathway</u>
- Rain falling onto the highway and surrounding areas will run overland towards the carriageway. The crossfall of the carriageway generally restricts the flow to the channel area adjacent to the kerbs.
- Water will flow down the carriageway channel until it enters a gully, whereupon it flows through the connection into the public sewer system or watercourse.

<u>Receptor</u>
During periods of exceedance the highway drainage network will fail either due to the lack of capacity of the gully or from the lack of capacity in the pipe system beneath. Both result in water being unable to enter the gullies leading to surface water running down the highway to the lowest point. Occasionally water will leave the system and will once again flow overland, although this usually only occurs under extreme conditions.

Normally the highway itself becomes the first receptor when it floods at the low point. If the storm continues, the flood depth will increase until the water level exceeds the ground level at the highway boundary at which point the flooding will spread onto neighbouring land which can result in property inundation. Properties that are situated lower than the highway are particularly vulnerable to this type of flooding.

5.5.4 Factors that determine highway drainage capacity

Considering the scenario as laid out above, the catchment area will have a major impact on the highway drainage network. Impermeable areas provide the majority of runoff in the urban environment although large permeable areas can also contribute particularly when the catchment becomes saturated. Many gardens and driveways fall towards the highway.
In recent years there has been a tendency for residents to increase the size of driveways and patio areas, thus increasing runoff, infill development has also exacerbated this problem, resulting in an increase in discharge towards the highway. This effect is known as urbanisation.

The effectiveness of the gullies to discharge water from the highway is determined by a number of factors including:-
- the longitudinal fall of the carriageway
- the crossfall of the carriageway
- the width of the carriageway
- the spacing of gullies along the channel
- the type of grating.
- the service condition of the gully (how clean of silt and debris the gully is)
- environmental factors such as the degree of tree cover in an area, or the proximity of field or open spaces near the highway. During heavy rain, leaves and debris will be

washed into the gully trap resulting in a loss of capacity, and ultimately the blockage of the outlet pipe.

The capacity of the pipe connecting the gullies to the main sewer will also have an impact on the overall capacity of the system. In much of Derby the gullies connect directly to the public sewer via a 150mm diameter gully connection pipe (or tail). In this case the highway drainage will normally have a far greater capacity than the associated sewer system, therefore the capacity of the gully, or its outlet, is not be the limiting factor. There are areas where the highway drainage connects to a highway carrier drain. The capacity of these systems is very variable. Modern systems will have been designed to the standards pertaining when they were installed, however, on some of the more ancient highways that still exist in Derby, the original highway was drained by highway ditches. As the highways were widened and footways added these ditches were often simply piped and gullies connected. These systems are generally very shallow and can therefore be in poor condition due to age and to root ingress from trees.

5.5.5 Risk Assessment of the Network

5.5.5.1 Highway pipe network

We are still in the early stages of logging the full extent of the highway drainage network, at this stage there is not sufficient information to carry out a full hydraulic check on the capacity of the network as a whole so this risk assessment will concentrate primarily on the service condition of the network. As part of the process of collecting data on the highway pipe network, manholes were inspected and any problems logged and the following issues identified:-

1. Complete or partial blockage in manhole,
2. Collapsed pipes
3. Direct flooding from manholes.

Figure 5.9 indicates those issues identified to date.

5.5.5.2 Highway Gully Network

With the highway drainage network now becoming available in GIS format it is possible to carry out a risk assessment of the Gullies that are most critical in preventing flooding. One method that can be used is to compare gully locations against the FMfSW flood outlines.

The 1 in 30 year deep flooding outline will identify the gullies that are most critical at reducing the impact of flooding. In these locations a flood depth in excess of 300mm is predicted in a 1 in 30 year storm, the condition of the highway drainage at these locations will have an effect on both the depth of flooding and the duration of the flooding. Figure 5.10 shows these critical gullies together with gullies within the 1 in 30 year shallow outline which could still have a significant impact on flood depth.

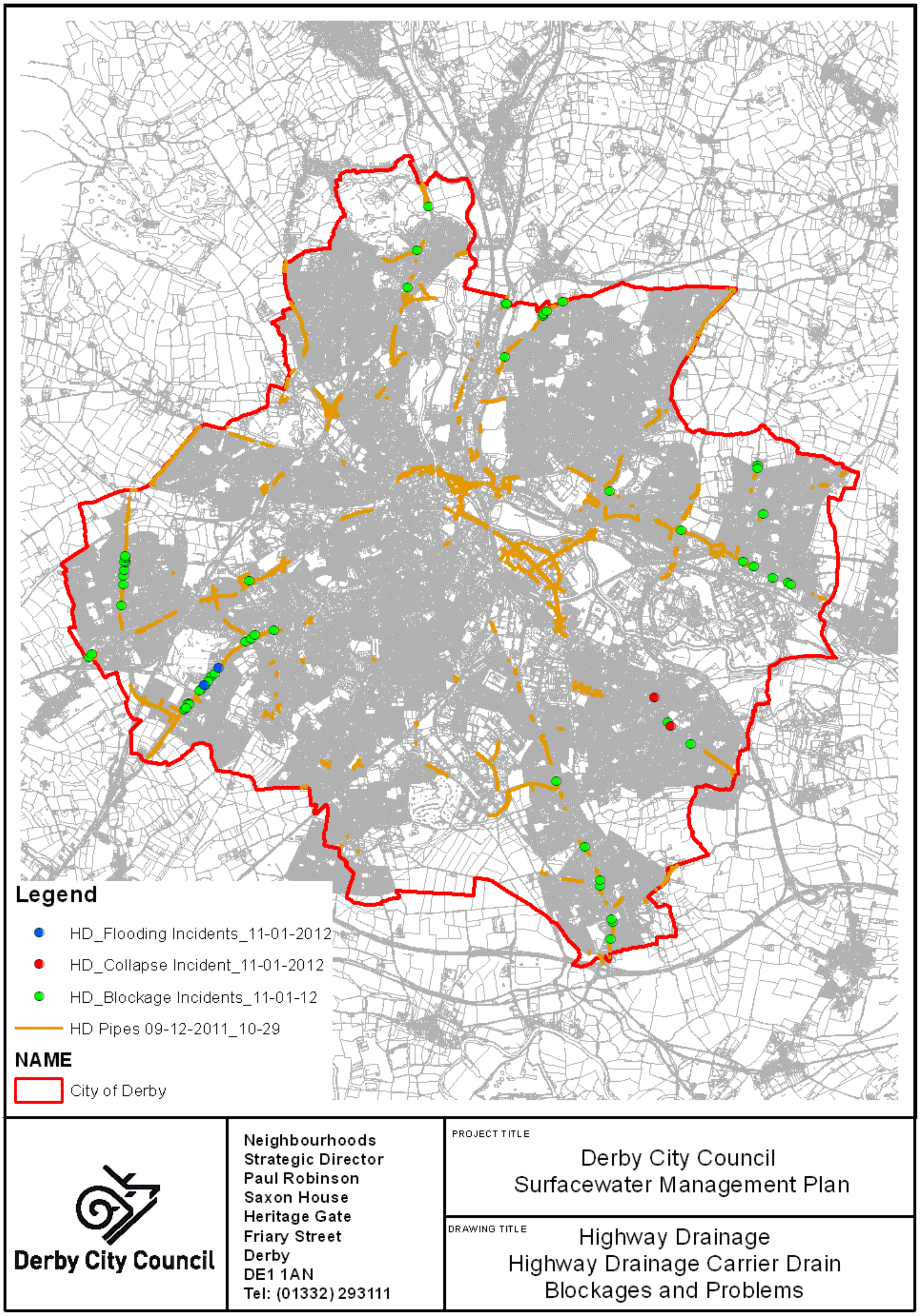

Figure 5.9 Recorded carrier drain issues

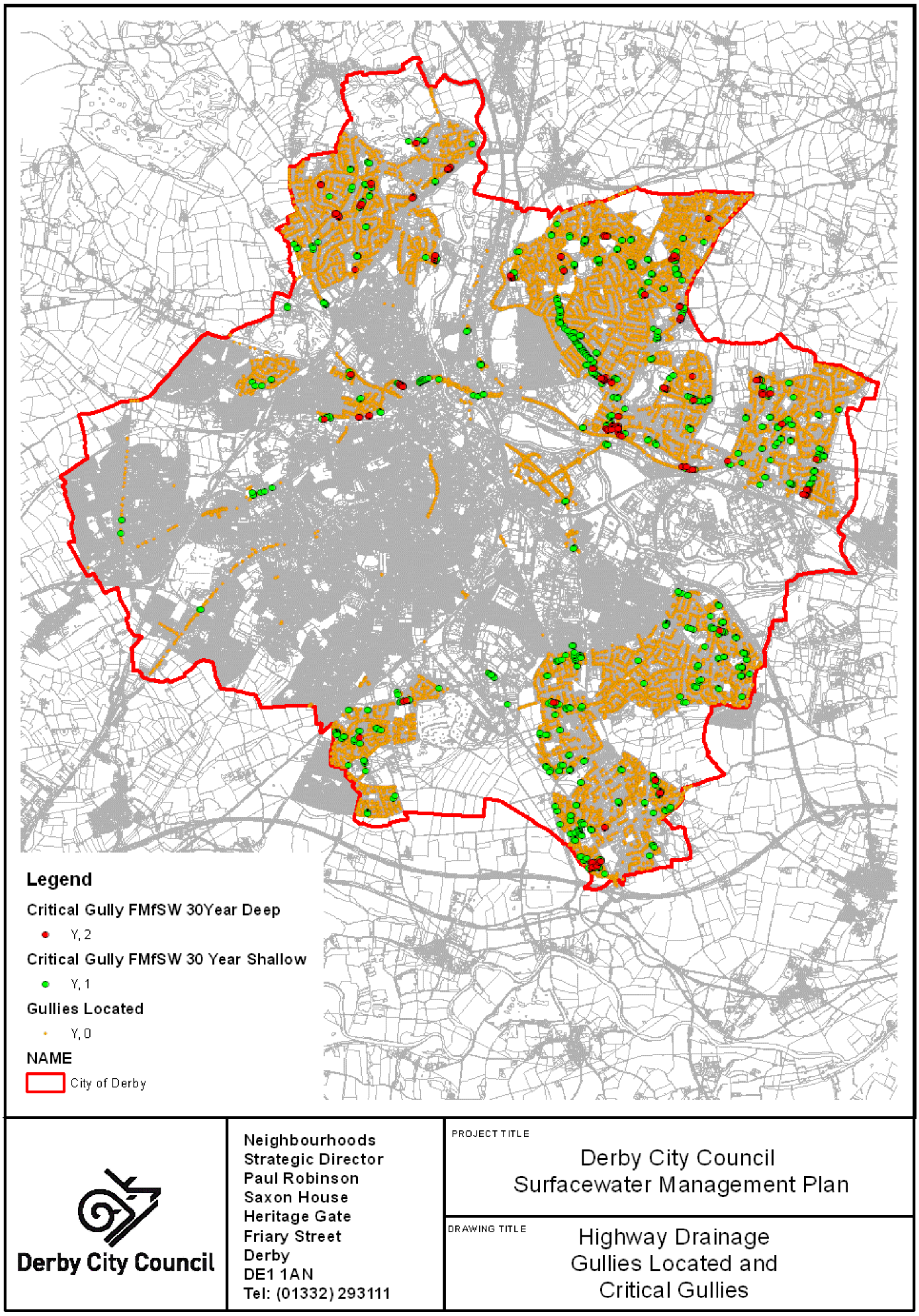

Figure 5.10 Recorded gullies with critical issues to date

5.5.6 Customer Perception of Highway Drainage

Derby City Council records all complaints and issues related to highway gullies. The following table gives the number of reported problems from last five years:-

5.13 Gully related incident schedule

Year	Number of incidents
2007	132
2008	240
2009	448
2010	484
2011	229

In 2009 due to budget restrictions Derby City Council reduced the number of gulley cleansing vehicles from two to one. This reduced the frequency that gullies were emptied from once a year to once every two years. It is possible that this decision lead to the increase in the number of gully incidents recorded. This frequency is less than that recommended by the Construction Industry Research and Information Association (CIRIA), Report 183 ref, which is used by many councils to set gully cleaning standards. The report states that there should be a normal cleansing frequency of between once and twice per year, but areas that are known to receive heavy sediment loads may be cleaned more frequently.

5.5.7 Policy Affecting the Management of the Highway Drainage System

River Trent Catchment Flood Management Plan (RTCFMP) sets the following objectives that are particularly relevant to highway drainage for the Derby City area policy unit 5 in the plan.

Reduce the disruption caused by flooding to the transportation network

Support and encourage land and drainage management that will protect and improve water quality, particularly from disused mines and derelict areas as well as heavily urbanised areas

River Basin Management Plan, Humber River Basin District set the follow action to deliver the objective of the plan which will impact directly on the highway drainage network.

Pressure	Description of the action			Lead Organisation and partners
	What willl happen	Where it will happen	Start Date	
Priority Hazardous Substances, Priority Substances and Specific Pollutants	Improved or more targeted street and drain cleaning and maintenance of storm water systems. For example, the Environment Agency and Highways Agency review of de-icing chemicals/ materials to identify products with minimal environmental impact, on the Birmingham motorway network.	Humber	2012	Highways Agency; Local Authorities; Environment Agency; Water companies

5.6 Private Drainage Systems

There are a number of commercial and industrial sites with private drainage systems which ultimately drain into the adopted sewer network. The status and condition of these private systems is difficult to gauge, as their maintenance is privately controlled and flooding occurrences are not publicly notified. Where property maintenance is poor, or properties are left derelict, the failure of drainage systems can result in surface water flooding of 3rd party properties. Since the inception of PPS25 in December 2006 there have been increasing requirements on developers to include some form of sustainable drainage system, together with suitable flow control. This will limit the discharge of surface water into the adopted system but if left unattended, will ultimately silt up, resulting in flooding of both the site in question and adjacent sites.
As part of any new development SuDS should be included within the design of the drainage system.

5.7 Reservoirs and Impounded Water

The three main reservoirs on the upper Derwent catchment lie well outside the jurisdiction of DCC, however, their operation and condition will have an impact on the river as it flows through the city. Within Derby lie Allestree Lake, and Markeaton Lake and immediately to the north of Derby lies Kedleston Lake (part of the Kedleston Park Estate). These all have potential effects on the local water infrastructure.

5.8 Groundwater Flood Risk

Groundwater flood risk varies across Derby. Much of the underlying solid geology consists of mudstones and siltstones of the Mercia group and is largely of extremely low permeability, however there are notable drift sediment deposits in certain areas. These principally occur along the principle river valleys of the Derwent and Trent, although some of the more prominent brook courses also have significant deposits. The highest potential for groundwater flooding is limited largely to the southeast of the city and can be seen in Figure 5.11

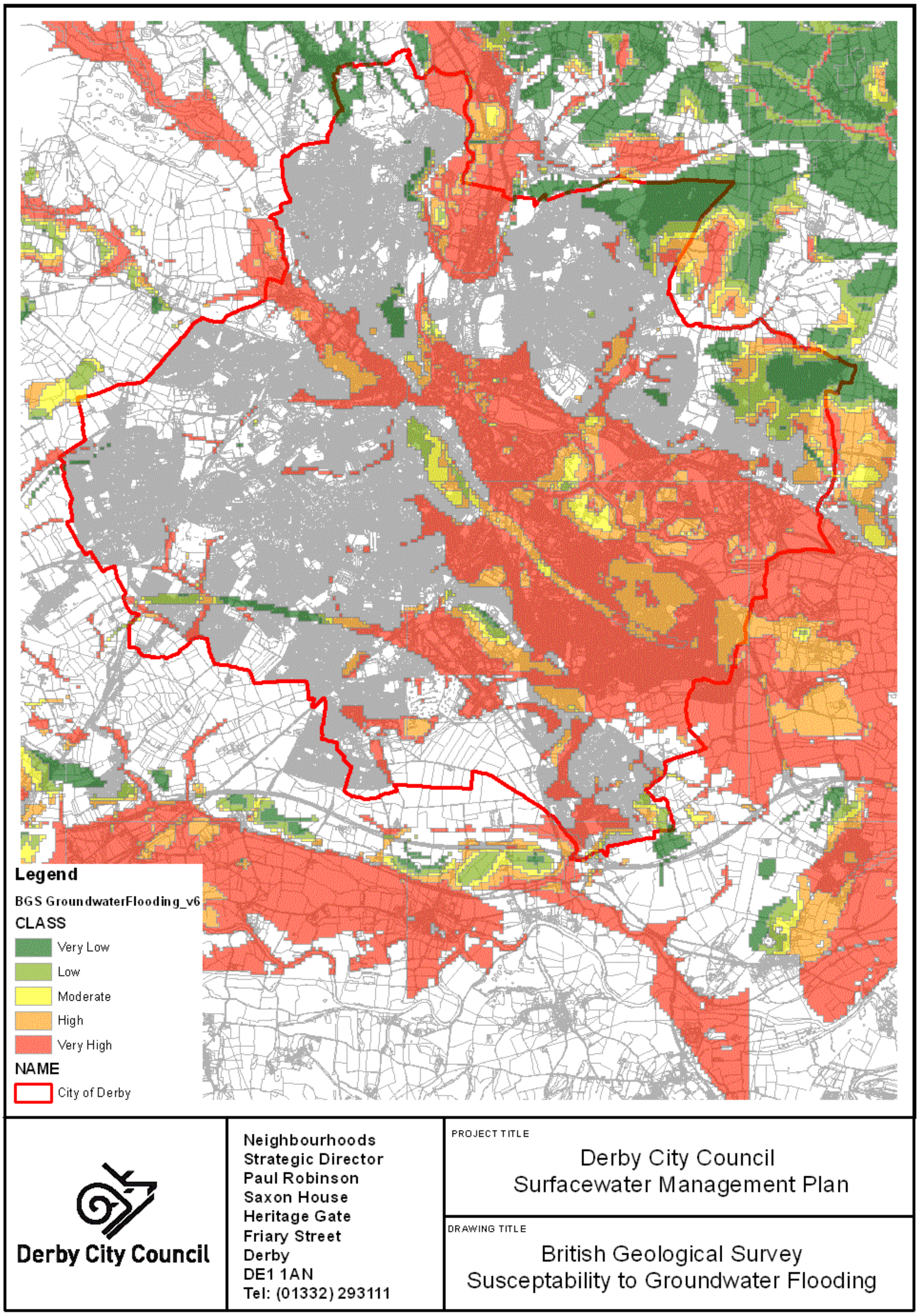

Figure 5.11 Susceptibility to groundwater flooding

5.9 Risk Summary

Source	Details	Areas at Risk
Fluvial	Flooding arising from out of bank flows, adjacent to culvert inlets or where capacity is limited by vegetation (or physical construction)	Low lying areas along banks or where levees are particularly flat.
Pluvial	Flooding caused by rain on any exposed area.	Large flat areas where sheet flows of water may occur or build up. (prevalent in cities)
Adopted Sewers	Flooding caused by insufficient capacity in systems, overflows to watercourses or emissions at ground level	Low lying areas where water may pool. Vulnerable properties.
Highway	Flooding caused by blocked or poorly maintained gullies	Highways and properties which lie below the level of the road, particularly in hollows.
Reservoirs	Not considered to be a significant issue.	No comment
Private Drainage	Inadequate or poorly maintained private systems, particularly where a company moves or goes bust.	Areas adjacent to private developments
Groundwater	Mainly on the southern parts of the city where land is flat and watercourses have little depth, or where old watercourses have been diverted from their original line.	Thackeray Street, Sinfin Moor, Boulton Moor, lower reaches of Hell and Cuttle Brooks.

6 Options

6.1 Introduction

The primary focus of this report has been to evaluate and collate all available information relating to flooding and the water infrastructure of Derby. With this in mind many of the following options relate to furthering and improving this information base. Once we know where we stand today, we can work to improve the condition and efficacy of the assets available. This will be a long-term process and will hopefully build year on year to give noticeable improvements.
Our secondary goal is to look at options for reducing flood risk in vulnerable areas, both for existing and new development.

6.2 Information Gathering

6.2.1 Three Cities asset management project

This scheme, currently undertaken by Nottingham, Derby and Leicester, will allow us to identify the location and condition of all gullies and gully connections in Derby. This in turn will allow a more organised or "hands on" approach to gully cleansing, and a more intelligent deployment of the cleaning teams. As this improved maintenance process gains momentum and pattern, it should be possible to identify the source of the receiving drain or sewer, and thus the ultimate mechanism by which each area is drained. The scale of this project is however immense and it will take some time before the full system has been surveyed, recorded and checked satisfactorily.

6.2.2 Connectivity

It is known that there are a number of very much smaller watercourses than those previously noted. Some of these are overgrown to the point of invisibility, and some have been culverted as part of historic development. We have already identified that a certain number have been abused by private service companies and/or developers, and are now causing flooding issues due to their lack of integrity, however, until these can be thoroughly identified, the extent of loss cannot be determined.

6.2.3 Topography

Existing LiDAR information for the city is now complete but often stops sharply at the city boundary. This can limit our understanding of the behaviour of surrounding areas in terms of overland flow characteristics. In addition, the development and re-development of areas of the city (such as the new inner ring road) will have changed the existing topography somewhat and hence the overland flow routes. Thought is currently being given to having parts (or all) of the city re-flown to get a complete up to date snapshot of the current alignment.
Derby's GIS database system is due to be replaced in 2012/3 and we are currently unsure how this will affect our ability to model assets and topography to a suitable degree, we are, however hopeful that our autonomy in this area will remain unchanged.

6.2.4 Hydrology Assessment

We are aware of the need to model/ monitor rainfall data in order to understand the behaviour of rainfall in Derby and some form of hydrology monitoring is essential. This may take the form of rain gauges or flow controls in certain catchments, possibly carried out in conjunction with Derby University.

6.2.5 Hydraulic Assessment

In conjunction with the hydrology study, it is proposed to construct a hydraulic model of the city's highway drainage assets. Initial thoughts are that this will be carried out using Infoworks ICM or a similar package, and will be carried out in-house. Initially we would look to incorporate such existing models as exist for the relative watercourses, but would seek to improve on these where possible. Extensive liaison with the EA will be required as many of the critical watercourses are under their stewardship.

6.2.6 Maintenance

Routine gully maintenance has suffered from a lack of coherent knowledge and organisation for some while, and it is hoped that the management for this will be shortly taken over by the Land Drainage team. Coupled with more up to date knowledge of the precise number, location and type of gullies it is hoped that a more structured cleaning schedule can be devised. Open watercourses and inlet screens are already monitored and cleaned regularly, and a small number of remote monitoring cameras are to be placed at particularly sensitive locations in the next few weeks. With this we hope to build a better picture of the operation of the surface water systems in Derby.

6.3 Flood Mitigation Options

6.3.1 Fluvial

Flooding will arise mainly from the drowning of outfalls, a lack of capacity, a lack of maintenance in open sections, the deposition of debris on trash screens or the collapse of culverted sections.

Aim to reduce the effects and frequency of flooding from fluvial sources, this may include the construction of dedicated river defences, the removal of obstructions, and the increased maintenance of culverts and inlet structures. There are various schemes already in place to facilitate this, however this will require time and man hours to implement.

6.3.1.1 EA Maintenance Contracts

This is a five year contract let by the EA aimed at ensuring the monitoring, cleaning and general maintenance of Main River watercourse assets within the city boundaries (not the Derwent or the Trent) and acting as emergency call-out staff for severe weather conditions. Currently, Derby City Council staff hold this contract, however this may change at the next renewal. It will be critical for any new contract holder to liaise with council staff as we have the local knowledge and will be the first point of contact for any complaint by the public.

6.3.1.2 General Screen and Culvert Maintenance

The monitoring, cleaning and periodic replacement of inlet trash screens and culverts, together with the clearing of rubbish and weeds from upstream areas, is of vital importance in maintaining good flow characteristics and preventing unnecessary flooding. This is managed "in house" by experienced council staff, using external contractors for specialist tasks, where appropriate.

6.3.1.3 Updating of Existing River Models

Existing watercourse models throughout Derby have been created by a variety of engineers, over a period of some years and may have different design criteria. We feel that the updating, testing and unification of these models into one Integrated Urban Drainage model is necessary to understand the exact behaviour of surface water flow in Derby.

Recent modelling of the combined Littleover/ Bramble Brook catchment is a case in point. Two separate models have been created using different computer systems, these need testing in greater depth to confirm their robustness and accuracy, and a combined flow model needs to be created. Moreover, there exist options for the diversion and storage of peak flows to limit flooding and accommodate downstream development.
Future modelling of several Main River watercourses is to be undertaken on behalf of the EA. These include the following brook courses:

- Cotton Brook, including its unnamed tributary
- Markeaton and Mackworth Brooks
- Chaddesden Brook
- Lees Brook
- Ock Brook (technically this lies outside the city boundary, however it may have future impact on development)

6.3.2 Pluvial

6.3.2.1 Surface Water Model

The FMfSW database model offers a good starting point to establish anticipated flood extents and baseline risk status, however, there are issues regarding the scale and sensitivity of the model, and questions over its precise adherence to actual topographical features. The following activities will allow Derby to improve on this data:

- in partnership with Derbyshire County Council and the EA, Derby City are looking to have the FMfSW model recalculated on a 1m grid, thus allowing for the gaps between buildings, and a more appropriate flow of water into the low-spots
- renewing the existing LiDAR information, reinforcing this with survey data from local companies where feasible, to give an up to date model of the city's topography
- obtaining digital "As Built" level surveys of all new developments in the city as part of the Development Control process
- detailed on-site investigation of vulnerable areas to assess how the risks can be mitigated. This may include:
  - the removal of any unnecessary interruptions to flow
  - the upgrading or construction of new drainage infrastructure
  - the adjustment of local site levels to discourage flooding of property.

6.3.2.2 Sewers

STW are currently updating their own model of Derby, and will be revising their assessment of future flood risk on this basis once complete. Derby will be in discussion with STW to assess how the revised risks affect the assets and citizens of Derby once this work is completed.

6.3.2.3 Highway Drainage

As stated, the collection of data relating to highway drainage assets is incomplete at this stage. The following actions are aimed at completing the critical knowledge:-

- completion of the asset location survey
- undertake further inspections to assess the condition of connections and carrier drains using combined CCTV and jetting teams
- identify the location of all publicly owned interceptors and ensure adequate cleaning/ maintenance, together with the tracing of related services.

6.3.2.4 Private Development

We must also look at ongoing, private and public development, and how this will affect, or will be affected by pluvial surface water flooding.

Table 6.1 shows a selection (not complete by any means) of the available methods of Flood mitigation, having due regard for the Source – Pathway – Receptor flood model.

Table 6.1 Stormwater Controls and Flood Resilience Measures

Tier of control	Type of Control	Comments
Source	Green/ Brown Roofs	New build – often meets resistance from traditional building market.
	Soakaway	Effectiveness dependant on soil type, may need to be very large.
	Swales	Very space orientated, can sterilise land if inappropriately placed
	Permeable Paving	Very good form of SuDS, but not always liked by developers.
	Rainwater Harvesting	Good if installed at outset, difficult to retrofit. Can be expensive, needs regular maintenance.
	Detention Basins	Very space hungry, needs designated POS
	Ponds and Wetlands	Very space hungry, needs designated POS
	Partial (or full) disconnection from sewer system combined with source control measure	Permeable paving/ soakaways/ filter drains can bee connected to increase flow path with high level discharge.
	Other measures	Filter drains, combinations can be good. Flood storage on site can be good. Increases flow path.
Pathway	Increased capacity of drainage system	Can be done on new systems but difficult on existing.
	Separation of foul and surface water systems	Difficult in urban areas, particularly if infrastructure already in place.
	Improved maintenance regimes	Increased man hours/ labour
	Land management practices	Very difficult in urban areas, but can create breaks in flow like raised tableaux at junctions and speed humps.
	Managing overland flows, sacrificial flooding of certain areas, and general water storage techniques	Designated flooding of parking areas to limit social harm (can also be done at source).
	Other measures	
Receptor	Improved weather warning	Can be provided by L.A.
	Planning policies to influence development	Input (and understanding) from planners.
	Use of temporary flood defences	Flood resilience, can be moderately cheap and retrofitted.
	Social change, education and awareness	Education,
	Improved resilience measures	Can be cheap and retrofitted
	Improved resistance measures	
	Evacuation plans	Emergency Planning
	Emergency planning/	Needs to be practised to be clear of

Tier of control	Type of Control	Comments
	community Flood Plans	options
	Other measures	

7 Action Plan

The aim of this action plan is to collate and organise the information presented thus far, to define the relative inputs and outputs together with a statement of ownership for each, and to develop a strategy for advancement. As stated previously, much of the work, either proposed or under way, is intended as further investigation work to enable council staff to build a better model for the local water infrastructure.

As stated, Derby does have a history of flooding. There are a number of identified sources for this, a large number of them outside the control of council staff. The first, and most critical task facing us is to complete the picture of where (and preferably when) flooding might be expected, and then to act to prevent it. Some of this can be done in phases, but some must wait for the bigger picture to be developed. The following sections are intended to give some indication of the order and extent of works required with a suitable timescale.

Table 7.1 Proposed actions

Source	Option	Timeframe	Benefit	Lead organisation
Gullies and highway drainage	The tracing of gullies throughout the city will allow us to plan the cleaning process more effectively and hopefully reduce costs.	Short	This has been going on for some 6 months and now covers approximately 60-65% of the city. We envisage that the initial stage will be complete towards April/ May 2012.	DCC Land Drainage
Connectivity	Tracing and assessing the numerous small drains and watercourses which mark former field boundaries or carrier drains.	Medium	This is important, as many of these old routes form the forgotten flood paths where stormwater collects. Many of these old channels have been lost or truncated by development resulting in flooding at odd times.	DCC Land Drainage
Topography	Updating the LiDAR data for the whole of Derby to give reasonably accurate contour information.	Medium	Because of the changes that are shaping the growth of the city, this needs to be carried out every few years or so in order to keep the information current. Extending it beyond the city boundary allows contributing areas to be included.	DCC or EA (as appropriate)
Hydrology	The inclusion of rain	Medium/	This is currently being	DCC/ EA

Source	Option	Timeframe	Benefit	Lead organisation
	gauges and/or flow monitors on critical watercourses will allow the measurement of rainfall and more accurate modelling of catchment behaviour.	Long	researched. We are seeking partners who will be happy to undertake rain modelling studies to assess the behaviour of various catchments	possibly with private partnerships
Hydraulic Assessment	It is proposed to build a digital model of the watercourses. Numerous models currently exist but some are outdated and some are considered inadequate.	Medium/ Long	This will take some time. It will be necessary to plan and accurately define the catchments, reaches, flow conditions and relevant boundary conditions prior to letting of contracts. Models must be designed such that they can interact and be adapted into a unified water model.	EA (main river models) STW (sewer models) DCC (IUD model)
Maintenance	The cleaning of existing drainage assets	Short/ Medium	With the control of gully cleaning now falling under the Land Drainage Team remit, it is hoped that the cleaning of gullies can be focussed where needed, so that particularly vulnerable areas are adequately looked after.	DCC Land Drainage/ highways maintenance
Rivers	Aim to reduce the effects & frequency of flooding from rivers and watercourses	Long term	This will require existing river models to be updated and may result in new river defences. It will take time and money but will ultimately improve our knowledge of the extents of flooding from watercourses.	EA
EA Maintenance Contracts	The critical maintenance of structures and assets for main	Ongoing	If the maintenance contract changes, there could be a loss in the continuity of the	EA/ DCC

Source	Option	Timeframe	Benefit	Lead organisation
	rivers, and the storm related clearance of such features.		service. This could result in flooding if not managed well.	
General Screen Cleaning	General and routine watercourse maintenance has been carried out for some years with removal of debris from trash screens and weed cutting to keep channels clear.	Ongoing	Maintenance is timed to keep channels clear of debris and minimise the potential for flooding.	DCC Land Drainage
Updated surface water model	The remodelling of the EA's FMfSW has begun, and is due to be completed in the next two months. Updating of LiDAR information. Updating of future "post-construction" information on new development.	Short/ Medium	Will allow much finer control of potential flood water, with less artificially retained behind buildings. Renewed LiDAR data will allow recent construction works to be included.	EA/ Derbyshire/ DCC
STW information	The proposed improvement to the Severn Trent Model will allow the future behaviour to be assessed.	Short	This is currently out of Derby's hands but we are in frequent contact with Severn Trent and their consultant.	STW
Future Development	The inclusion of SuDS into new developments (courtesy of PPS25) means that new developments will be built with communal SuDS schemes, which will need to be adopted by the local authority.		The imminent appointment of Derby to the position of SuDS approving body (SAB) means that we will be in a position to comment, advise and (where appropriate) approve new SuDS schemes.	Central Government

8 References

1. Learning to Live with Rivers – Institution of Civil Engineers
http://www.ice.org.uk/Information-resources/Document-Library/Learning-to-live-with-rivers

2. Making Space for Water – Environment Agency
http://archive.defra.gov.uk/environment/flooding/documents/policy/strategy/strategy-response1.pdf

3. PPS25 Development and Flood Risk – Environment Agency
http://www.communities.gov.uk/publications/planningandbuilding/pps25floodrisk

4. The PITT Review (Lessons Learned from the 2007 Floods) – Environment Agency
http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html

5. 2007 Census uk
http://www.statistics.gov.uk/census2001/cn_155.asp

6. Derby City Council Level 1 Strategic Flood Risk Assessment (SFRA)

7. Flood Risk Assessment Guidance for New Development (FD2320) – DEFRA
http://www.hydres.co.uk/

8. DEFRA website
http://www.defra.gov.uk/environment/quality/water/sewage/sewers/