London Borough of Sutton
Surface Water Management Plan

Phase I & II – Final Report
July 2010




Prepared for

Sutton

Revision Schedule

Surface Water Management Plan: Phase I & II
July 2010

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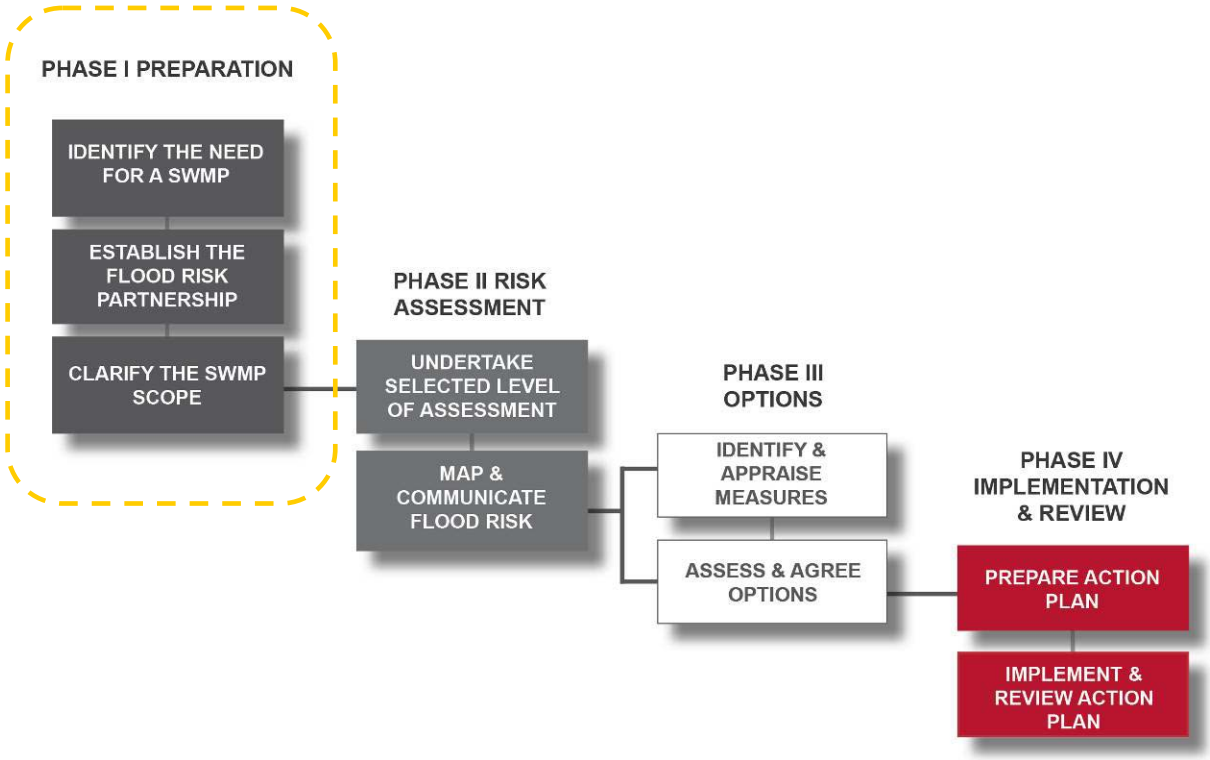
Abbreviations

ACRONYM	DEFINITION
AAP	Area Action Plan
CDA	Critical Drainage Area
CIRIA	Construction Industry Research and Information Association
CFMP	Catchment Flood Management Plan
CLG	Government Department for Communities and Local Government
Defra	Department for Environment, Flood and Rural Affairs
DEM	Digital Elevation Model
EA	Environment Agency
IUD	Integrated Urban Drainage
LBS	London Borough of Sutton
LDF	Local Development Framework
LiDAR	Light Detection and Ranging
LPA	Local Planning Authority
LRF	Local Resilience Forum
PPS25	Planning and Policy Statement 25: Development and Flood Risk
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Glossary

TERM	DEFINITION
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
Asset Management Plan	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding.
Critical Drainage Area	Areas of significant flood risk, characterised by the amount of surface runoff that drains into the area, the topography and hydraulic conditions of the pathway (e.g. sewer, river system), and the receptors (people, properties and infrastructure) that may be affected.
Culvert	A channel or pipe that carries water below the level of the ground.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Floods and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Rate Support Grant	Funding mechanism from CLG to Local Authorities which provides funding for all Local Authority responsibilities.
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.

PHASE I: PREPARATION



1 Identify the Need for a SWMP

1.1 Introduction

1.1.1 The principal output from a Surface Water Management Plan (SWMP) is essentially a plan which outlines the preferred strategy for the coordinated management of surface water flood risk within a given area[1], in this instance London Borough of Sutton. In the context of the SWMP, surface water flooding incorporates flooding from sewers, drains, groundwater, and runoff from land, small ordinary water courses and ditches occurring as a result of heavy rainfall.

1.1.2 The SWMP Technical Guidance issued by Defra in March 2010 emphasises that SWMPs may not be required in all locations. Studies should be prioritised in areas considered to be at greatest risk of surface water flooding or where partnership working is essential to both understand and subsequently address surface water flooding issues.

1.1.3 The remainder of this chapter therefore provides an overview of the rationale behind the preparation of a SWMP for London Borough of Sutton including, the history of surface water flooding; the complexity of flooding mechanisms in the borough due to drainage system interactions; the fragmented nature of asset management; proposed future urbanisation and redevelopment in the borough; as well as the impacts of existing and emerging policy and legislation.

1.2 History of Surface Water Flooding

1.2.1 According to national research undertaken by Defra[2], Sutton is ranked the 30th settlement in England most susceptible to surface water flooding, with as many as 9,900 properties estimated to be at risk.

1.2.2 The Strategic Flood Risk Assessment for London Borough of Sutton[3] identifies significant surface water flooding from the summer 2007 flood event when intense rainfall exceeded the capacity of the existing drainage systems, and led to substantial overland flow and ponding of surface water in low lying areas. Drainage systems were overwhelmed in several locations across the borough in 2007, 2008, 2009 and 2010 most notably in Beddington, Worcester Park and Wallington.

Figure 1-1 Surface Water Flooding in Wallington, July 2007

[1] Defra (March 2010) Surface Water Management Plan Technical Guidance www.defra.co.uk
[2] National Rank Order of Settlements Susceptible to Surface Water Flooding, Defra 2009
[3] Scott Wilson Group (2009) Strategic Flood Risk Assessment for London Boroughs of Wandsworth, Merton, Sutton and Croydon

1.2.3 Furthermore, as part of the borough's Flood Plan, as many as 26 discrete locations have been identified within the borough as at risk of flooding due to gullies easily becoming blocked or a lack of capacity during intense rainfall events.

1.2.4 Media and meteorological research carried out as part of the Local Climate Impact Profile (LCIP) for London Borough of Sutton[4] identified 35 reports of heavy rain and flooding in the borough between January 1998 and December 2008. The two most significant events were on 15th September 2000 (58mm rain) and 20th July 2007 (over 40mm rain). During the July 2007 event, the volume of rainfall exceeded the design capacity of the urban drainage system and urban watercourses and caused widespread damage to more than 1,200 properties and extensive disruption to transport systems[5] . Residents were displaced from their homes and boil notices were issued when the risk of water contamination was identified.

1.2.5 Under UKCIP02, predictions for future rainfall for the Sutton area up to 2050 are for up to 15% more winter precipitation. Heavier winter precipitation is expected to become more frequent with 0.25-0.75 more days of 'intense' rainfall (i.e. over 20mm). The risk of exceedence of the urban drainage system and surface water flooding in the borough is therefore likely to increase into the future unless steps are taken to manage and mitigate this form of flooding.

1.3 Drainage System Interactions

1.3.1 In the context of SWMPs, surface water flooding incorporates flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches occurring as a result of heavy rainfall. These sources may operate independently or through a more complex interaction of several sources.

1.3.2 An initial overview of the flooding issues in LB Sutton reveals areas that are affected by multiple sources of flood risk and complex interactions between urban watercourses, direct surface water ponding, overland flow paths and the surface water sewer system. One such example is the Hackbridge area which is susceptible to groundwater flooding, surcharge of the surface water drainage system as well as direct surface water flooding from rainfall that contributes to overland flow-paths.

1.3.3 In order for these flooding mechanisms to be adequately assessed, a holistic approach to surface water management is required. The SWMP approach will seek to ensure that all sources and mechanisms of surface water flood risk are assessed and that solutions are considered in a holistic manner so that measures are not adopted that reduce the risk of flooding from one source to the detriment of another.

1.4 Fragmented Responsibilities

1.4.1 In areas of multiple sources of flood risk and complicated interactions between different sources of flooding, there are likely to be multiple water or drainage regulators, owners and maintainers. In LB Sutton there are numerous partners with responsibility for decisions regarding drainage assets and areas at risk of flooding including the London Borough of Sutton (the Council), the Environment Agency, Thames Water, Transport for London and Sutton and East Surrey Water.

1.4.2 It is essential that all relevant partners with responsibility for making decisions and taking actions are involved in plans for flood risk management from the outset. The purpose of the SWMP for LB

[4] EcoLocal (May 2009) Local Climate Impact Profile (LCLIP) for London Borough of Sutton
[5] LB Sutton (September 2007) Report of the Chief Executive – Flooding on Friday 20th July 2007

Sutton is to strengthen the partnership between these organisations and ensure inclusivity through all phases of this study and future flood risk management in the borough.

1.5 Future Urbanisation and Redevelopment

1.5.1 LB Sutton's Core Strategy was adopted in December 2009 and sets out the vision for the future of the borough including broad locations for development. The Core Strategy seeks to focus redevelopment and economic growth in the borough's town and district centres of Sutton, Worcester Park, Carshalton and Wallington. Redevelopment in these areas will benefit from a good range of facilities and public transport links as well as help to protect the character of high quality residential areas in the suburbs.

1.5.2 In addition, a vital part of the vision is the regeneration of Hackbridge into the UK's first sustainable suburb. LB Sutton have commissioned a Masterplan for Hackbridge[6] that will provide an evidence base for substantiating the council's policy approach for a growth area in Hackbridge as part of the Core Planning Strategy; and produce detailed proposals for the future development of Hackbridge that will feed into the emerging Site Development Policies Development Plan Document and ultimately the Hackbridge Supplementary Planning Document.

1.5.3 These plans for urbanisation and redevelopment within LB Sutton present a significant challenge to the existing drainage systems. However, it is also affords a crucial opportunity to address long-standing issues and problems relating to surface water flooding and pressure points on the drainage system through strategic improvements and upgrades to the drainage system.

1.5.4 The SWMP for LB Sutton should afford a particular focus on these areas allocated for further development and urbanisation and identify any potential locations for strategic improvements and upgrades to the existing drainage systems.

1.6 Existing & Emerging Legislation

1.6.1 Following the flooding in July 2007, the Government commissioned Sir Michael Pitt to undertake an independent review into the causes and management of flood risk in the areas affected. The Flood and Water Management Act is designed to put into place the changes recommended by Sir Michael Pitt in his review and aims to reduce the risk and impact of flooding; improve the Local Authority's ability to manage the risk of flooding; improve water quality; and reduce pollution.

1.6.2 The Flood Risk Regulations 2009 came into force in December 2009 and are a set of regulations which translate the EU Floods Directive into law for England and Wales. The Regulations bring the Environment Agency, County Councils and Unitary Authorities together with partners such as water companies to manage flood risk from all sources and to reduce the consequences of flooding on human health, economic activity, cultural heritage and the environment.

1.6.3 All these documents; Sir Michael Pitt's review of the Summer 2007 floods, the subsequent Flood and Water Management Act and the Flood Risk Regulations 2009, emphasise the need for local authorities to embrace a leadership role for local flood risk management, ensuring that flood risk from all sources, including flooding from surface water, groundwater and small watercourses, is identified and managed as part of locally agreed work programmes.

1.6.4 In accordance with these recommendations and emerging requirements LB Sutton has begun the process of preparing a Surface Water Management Plan for the borough.

[6] Tibbalds Planning & Urban Design et al. (January 2009) Hackbridge Sustainable Suburb Final Draft Masterplan

1.7 Summary

1.7.1 LB Sutton has a history of widespread and severe surface water flooding. There are multiple and interlinked sources of flooding in the borough which require holistic management and solutions and which therefore require the engagement of multiple responsible organisations from an early stage in the flood risk management process. In addition, plans to increase the level of development within the main centres of Sutton, Carshalton, Wallington, Worcester Park as well as regeneration of the Hackbridge area will result in additional strain on an already overloaded drainage system. It is therefore crucial that issues relating to surface water flooding are addressed when and where new development is proposed to maximise the potential for strategic improvements such as flood storage, SUDS retrofit, and/or upgrades to the drainage system.

1.7.2 On top of these issues, existing and emerging legislation strongly advocates the leadership role of local authorities in local flood risk management and the preparation of SWMPs where there is a clear need.

1.7.3 In the light of these factors, it is evident that further works needs to be undertaken to address surface water flooding issues in the borough and develop a strategy for urban surface water management that is evidence based, risk based, future proofed and inclusive of stakeholder views and preferences. This is the purpose of the London Borough of Sutton Surface Water Management Plan.

2 Establish the Flood Risk Partnership

2.1 Sutton Flood Group

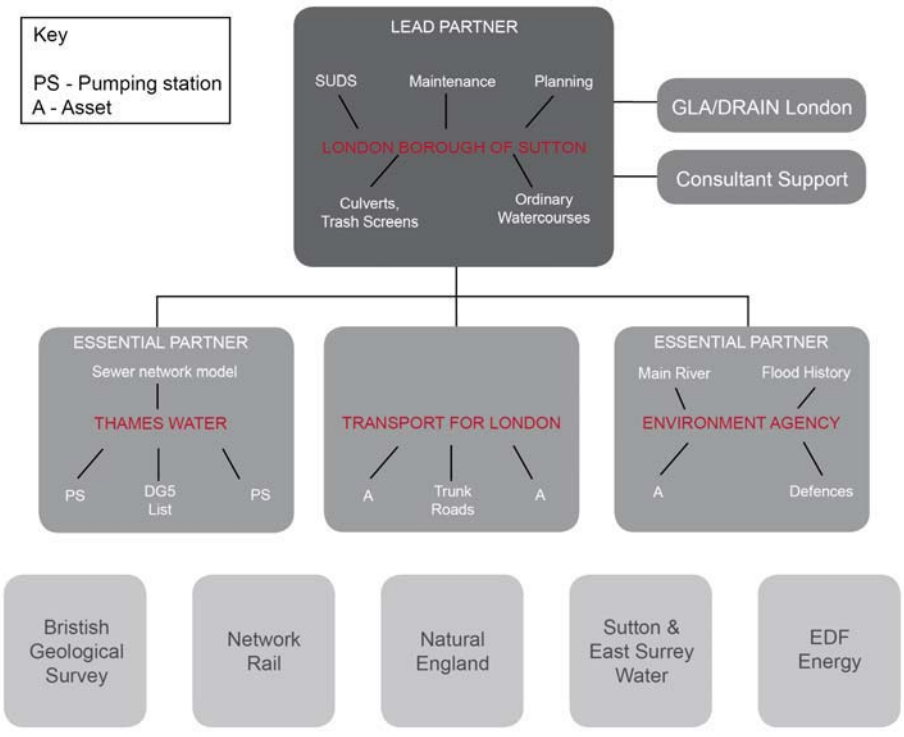
2.1.1 In order for the SWMP study and future flood risk management more generally within Sutton to be successful, it is essential that relevant partners and stakeholders, who share the responsibility for necessary decisions and actions, work collaboratively to understand existing and future surface water flood risk in the borough.

2.1.2 The Sutton Flood Group comprises representatives from the Environment Agency, Thames Water as well as multi-departmental representation from the London Borough of Sutton including environmental sustainability, strategic planning, emergency planning, parks and open spaces, and highways drainage. The flood group was set up by the Council following the summer floods of July 2007 with the aim of ensuring collaborative working across relevant stakeholders as described above.

2.2 Suggested Flood Risk Partnership Members

2.2.1 LB Sutton's SWMP study will build upon the partnerships established through the Sutton Flood Group and will seek to incorporate additional partners and stakeholders as they are identified throughout the SWMP study. It is proposed that the Sutton Flood Group be expanded to include Transport for London (TfL) given that approximately 5% - 10% of the drainage assets within Sutton are owned by TfL. Similarly, Sutton and East Surrey Water operate several groundwater extraction wells which have an impact on local groundwater levels in the borough and have therefore been invited to join the Sutton Flood Group as another important partner organisation. The expected potential extent of the local flood risk partnership for LB Sutton is illustrated in Figure 2-1.

Figure 2-1 Suggested Local Flood Risk Partnership



2.3 Benefits of Collaborative Working

2.3.1 A number of benefits will arise from the collaborative working between members of the Sutton Flood Group, including:

- Greater understanding of urban drainage by a range of organisations;
- A shared understanding of flood risk across the Council, Thames Water and the Environment Agency;
- Efficiency savings for 'essential partners' though achieving outcomes;
- Appraisal of surface water drainage options;
- Greater certainty for developers concerning appropriate drainage;
- Quicker, more certain decisions on development and infrastructure provision; and
- Overall reduction in flood risk to LB Borough of Sutton (primarily driven through the latter SWMP phases III and IV – dependent upon available funding).

2.4 Project Governance Framework

2.4.1 The Sutton Flood Group has two main functions;

a. A strategic function to contribute to the delivery of the SWMP by establishing a shared understanding of flood risk and agreeing a coordinated approach to reduce the risk; and,

b. An operational function to improve the co-ordination of flood incident management and emergency response.

2.4.2 A project governance framework has been prepared[7]. This document sets out proposed roles and responsibilities for 'essential partner' organisations including Thames Water and the Environment Agency, as well as the objectives and terms of reference of the Flood Group, and proposed lines of communication.

2.4.3 This document is included in Appendix B and should be consulted for more detailed information regarding the working relationship between key partner organisations throughout the completion of the SWMP and for future flood risk management.

[7] Scott Wilson Group (July 2010) Project Governance Framework

3 Clarify the SWMP Scope

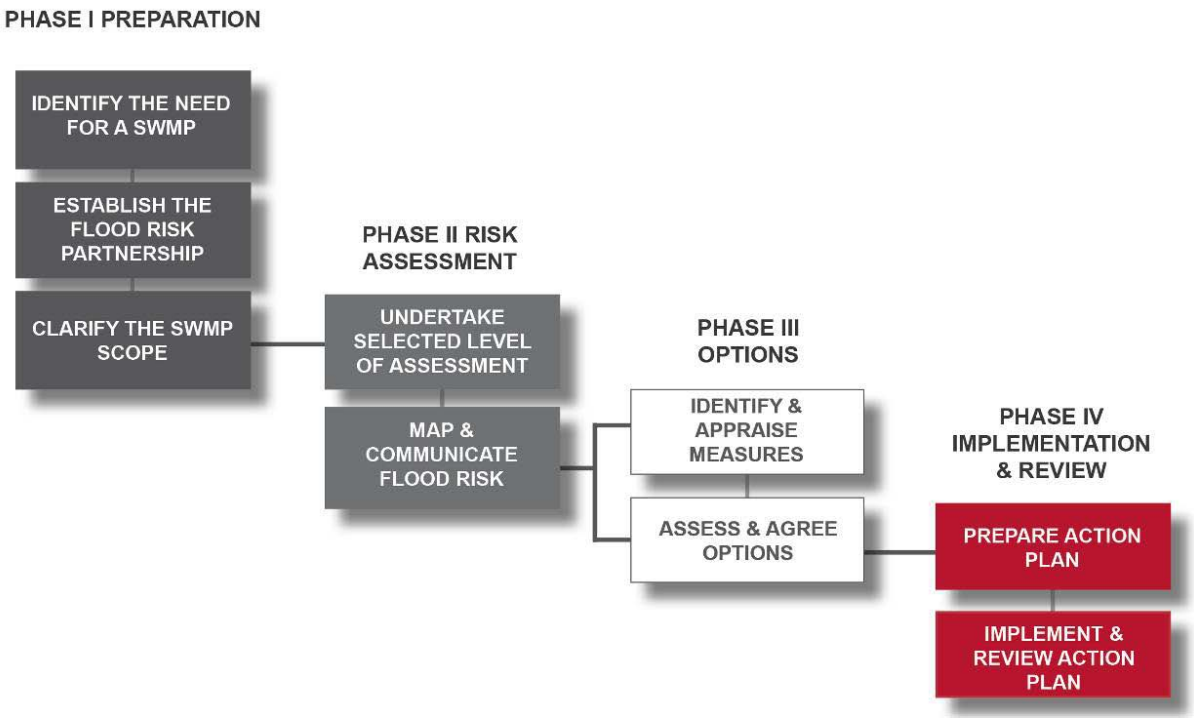
3.1 Structure

3.1.1 The principal output from a Surface Water Management Plan (SWMP) is an action plan which outlines the preferred strategy for the coordinated management of surface water flood risk within a given area.

3.1.2 The Defra SWMP Technical Guidance identifies four key phases of a SWMP as shown in

3.1.3 .

Figure 3-1 Phases of SWMP



3.1.4 The first three phases involve undertaking the ‘SWMP study’, whilst the fourth phase involves producing and implementing the ‘action plan’, founded on the evidence base of the Phase I – III SWMP study.

3.1.5 This report constitutes Phase I (Preparation) and Phase II (Risk Assessment) SWMP for LB Sutton. However, an indicative element of Phase III (Options) has been included as an added value measure within this report. This was included to help to identify any SWMP ‘early actions’ and to assist with the co-ordination of initial options through to the Drain London study and to ensure the outputs from the SWMP study for London Borough of Sutton are focused and practical. However, it is stressed that a full Phase III SWMP is beyond the scope of this commission and would require further assessment.

3.2 Aims & Objectives

3.2.1 The following objectives have been developed for each phase of the LB Sutton SWMP;

3.2.2 Phase I – Preparation

- Identify the specific needs for a SWMP in LB Sutton and the determine the local project drivers;
- Build upon the established Flood Group to continue to develop a joint understanding of flood risk within the borough and overcome the division of responsibility in urban drainage;
- Collate and map existing information regarding flood risk from all sources;
- Determine an appropriate level of assessment for the Sutton SWMP.

3.2.3 Phase II – Risk Assessment

- Undertake suitable modelling approach to enable an intermediate assessment of surface water flood risk in the borough;
- Quantify the risks from surface water flooding through the identification of overland flow paths and areas of surface water ponding leading to an assessment of properties and infrastructure at risk;
- Map the results of the pluvial modelling;
- Communicate flood risks to relevant bodies within the local flood risk partnership;
- Provide recommendations for detailed risk assessment if appropriate.

3.2.4 Phase III – Options

- Provide initial identification of potential options for surface water management in the borough;
- Advise on 'early actions' or practical solutions that can be implemented;
- Advise on the potential for Integrated Drainage Strategies for strategic development sites.

3.3 Linkages with Other Plans

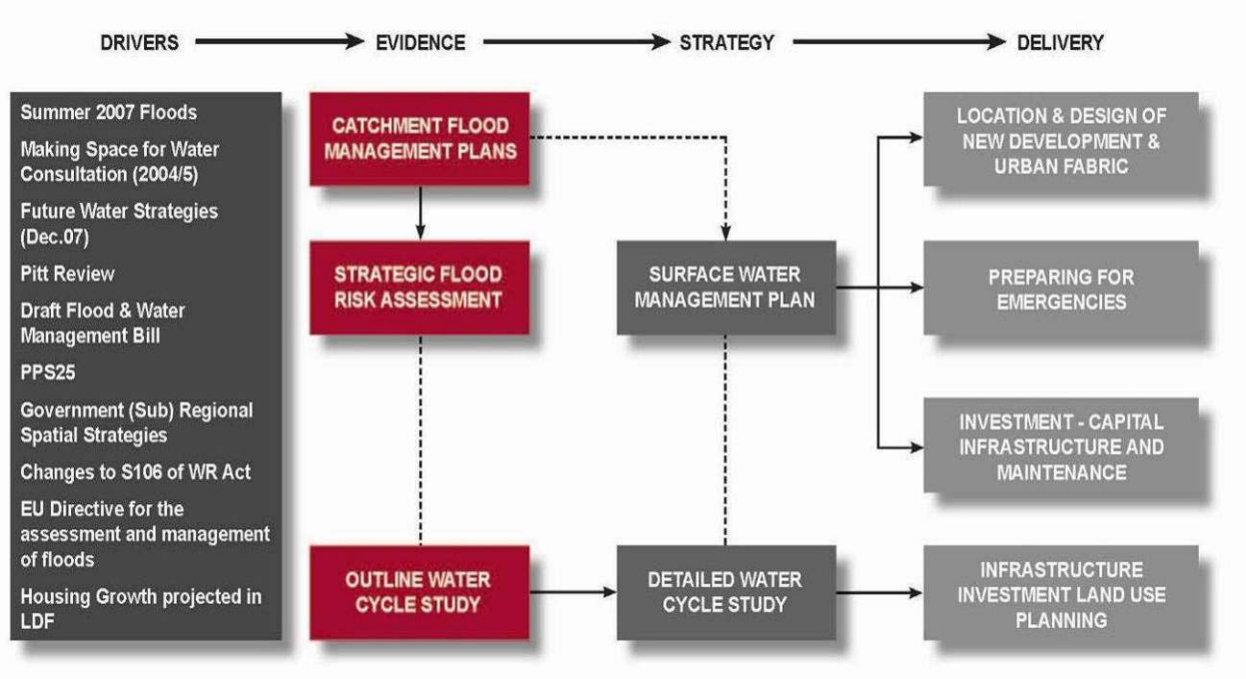
3.3.1 It is important that the SWMP is not viewed as an isolated document, but one that connects with other strategic and local plans. Figure 3-2 below shows Scott Wilson's interpretation of the drivers behind the Sutton SWMP, the evidence base and how the SWMP supports the delivery of other key spatial planning and investment processes.

Environment Agency Plans

River Basin Management Plan

3.3.2 The River Basin Management Plan for the Thames River Basin District addresses the pressures facing the water environment in the district and the actions required to protect and improve the water environment. This plan has been developed in consultation with a wide range of organisations and individuals and is the first of a series of six-year planning cycles. The first cycle will end in 2015 when, following further planning and consultation, this plan will be updated and reissued.

Figure 3-2 'Where SWMPs Fit In' Scott Wilson [2009]



Thames Catchment Flood Management Plan

3.3.3 The Thames Catchment Flood Management Plan was published in 2008 and sets out policies for the sustainable management of flood risk across the whole catchment over the long-term (50 to 100 years) taking climate change into account. The Plan emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally.

3.3.4 This Plan will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchment.

The CFMP Policy Unit for the Wandle and Beverley Brook

3.3.5 The Thames CFMP Policy Unit for the Beverley Brook and Wandle through Sutton is 'P4 – accept the risk' – but in the long term take action to ensure that risk does not increase from current level. The Beverley Brook and Wandle Policy Units are characterised by highly developed floodplains with little open space and modified river channels. Also, these urban areas are very susceptible to rapid flooding from thunderstorms. Emergency response and flood awareness are particularly important. Furthermore, urban flooding is likely to increase in the future as a result of:

1. Ageing drainage infrastructure;
2. More development covering previously permeable ground;
3. Increase in paving in existing developments e.g. patios and driveways; and
4. Climate change i.e. wetter winters and heavier summer rainfall.

3.3.6 Specific CFMP actions are detailed below:

- Long-term adaptation of the urban environment is required;
- There are opportunities to reduce flood risk through redevelopment. In most areas we need to change the character of the urban area in the floodplain through re-development. It must be resilient and resistant to flooding and result in a layout that recreates river corridors; and
- Identify and seek out opportunities to re-create river corridors through redevelopment so that there is space for the river to flow more naturally and space in the floodplain where water can be attenuated.

London Borough of Sutton Plans

Core Planning Strategy

3.3.7 The Core Planning Strategy presents the spatial vision, strategic objectives and policies for growth in the borough over the next 15 years, including locations for proposed new housing, retail and business development. This document has been through three rounds of consultation and was adopted in December 2009. As plans progress within each of these broad areas allocated for growth and regeneration, the findings of the SWMP should be considered and implemented as appropriate.

Strategic Flood Risk Assessment [2009]

3.3.8 In collaboration with the Environment Agency and neighbouring boroughs of Wandsworth, Merton and Croydon, LB Sutton has co-ordinated the preparation of a joint SFRA for the Wandle catchment. The SWMP builds upon the evidence base supplied in the SFRA with respect to surface water flood risk.

National Indicator 189

3.3.9 The London Borough of Sutton has been issued a target to deliver a Surface Water Management Plan (SWMP) as part of their local agreement under National Indicator (NI) 189. The NI 189 targets are periodically reviewed and progress is monitored by the Environment Agency. The Phase 1 & 2 SWMP along with the project governance framework should help to solidify the working and operational arrangements between the Environment Agency, Thames Water and the Council.

Multi-Agency Flood Plan

3.3.10 Representatives from the Emergency Planning Team at LB Sutton have confirmed that they are awaiting the completion of the SWMP to inform the preparation of their Multi-Agency Flood Plan for the borough.

Thames Water Plans

3.3.11 During the preparation of this Phase I and II report plans have not been received from the water and sewerage company. Documents that would be useful to the flood risk partnership include the following:

- Drainage Area Plan
- Sewerage Management Plan
- Asset Management Plan

3.4 Stakeholder Engagement

3.4.1 For the purpose of the SWMP a stakeholder is defined as anyone affected by, or interested in the surface water problem or proposed solution. Stakeholders are often individual homeowners but they can include organisations, the public and communities. Different stakeholders should be engaged with to provide a rounded view of the problem and proposed solution.

3.4.2 It is important that the Council liaise with stakeholders as an on-going process as they have often experienced flooding first hand and can provide invaluable information. Also, to ensure the smooth running and effective implementation of potential mitigation measures (especially those which may lead to local disruption e.g. road works) stakeholder engagement is required from the start.

3.4.3 The SWMP process supports liaison with local stakeholders throughout the process however, it also highlights the importance of managing their expectations.

3.4.4 Following the July 2007 flood event, members of the public and homeowners who had been flooded were contacted by the LB Sutton. Information gathered at this time has been used to inform the SWMP study. Since the 2007 flood event, the Council has held regular meetings with affected residents. The most recent meeting with residents on the 2nd of March 2010 was to discuss the progress of the surface water management plan meeting with residents. A copy of the Council's letter to residents is contained in Appendix A.

3.4.5 It is suggested that as the SWMP continues to moves forward to Phases III and IV (options and implementation stages), that local stakeholders are contacted for their views on flood risk mitigation options and to exchange ideas about what they would like to see as potential outcomes. It is recognised that future SWMP Phases III and IV work may be carried out on behalf of the Council by the Greater London Authority through the Drain London project.

3.4.6 The following engagement priorities are suggested to be taken forward by the Council:

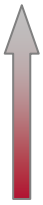
- Engage with stakeholders to raise the profile of flood risk – potentially through a leaflet drop;
- Provide a single point of contact at the Council for surface water drainage problems to be reported to;
- Provide a newsletter/leaflet to promote schemes that the Council have completed in order to reduce existing flood risk;
- Formally engage with local stakeholders via public meetings at the options stage. This should include details of the Councils proposals as well as information on how homeowners can protect themselves against flooding;
- Hold an open evening when different partners attend including Thames Water, Environment Agency, Transport for London and the Council to describe what actions each organisation are taking & answer questions from the public.

3.5 Data Review

3.5.1 One of the key components of a shared understanding of flood risk is the sharing of flood risk data between and across organisations. This section sets out the results of our comprehensive data collection and review.

3.5.2 Data has been collated, recorded and analysed, chiefly by Scott Wilson. Data collected has been recorded in a project data register which documents the source of the data and its completeness.

In line with the SWMP technical guidance (Defra 2009), the quality of the data has been scored using the following classifications:



1. No known deficiencies - not possible to improve in the near future.
2. Known deficiencies – best replaced as soon as new data are available.
3. Assumed – based on experience and judgement.
4. Grossly assumed – an educated guess.

Table 3-1 Data Register

Category	Data / Information	Source	Provided	Details	Format	Quality	Comments
Asset Data and Information	Highway drainage records	Upper tier highway authority					
	'Ordinary watercourses'	Lower tier drainage departments, Internal Drainage Boards					
	Maintenance regimes and records	All partners	✓	Highways Improvement Works after July 2007 Flooding		1	
	River or coastal models and asset data	Environment Agency	✓	Flood outlines for the River Wandle and Beverley Brook	GIS	2	Revised 2D modelling is currently being undertaken for the River Wandle.
	Foul / combined surface water models	Water and sewerage companies					
	Drainage asset data	Water and sewerage companies					
	Information on local watercourses	Internal Drainage Boards	✓	River Wandle Catchment Asset Information Plan – Phase 1 & 2	PDF	1	
				Beverley Brook Asset Information Plan	PDF	1	
	Location of critical infrastructure	Local Resilience Forums					
	Borehole records	Environment Agency					
Background Information	OS Mapping data	Local authorities have licence for this data	✓	50,000, 10,000 and OS Mastermap	GIS	1	
	Ground data	Any of the partners may hold this	✓	2m resolution Light Detection and Ranging (LiDAR) data	GIS	1	
	Areas Susceptible to Surface Water Flooding Mapping	Local Planning Authority	✓	ASSWF coverage for LB Sutton	GIS	2	
	Supporting Documents	All partners	✓	Drain London Scoping Study and Data Assessment Report v3.0	PDF	1	
	Geological data	Environment Agency	✓				
	Aerial photography	Any of the partners may hold this	✓				
	Ward Boundaries	Local authority	✓				
	Parks and Open Spaces	Local authority	✓				

Category	Data / Information	Source	Provided	Details	Format	Quality	Comments
Historical Information	Historic flood incident data	All partners should hold this	✓	July 2007 Flood Report	Word Doc	2	Incidents are not geo-referenced.
				Sutton Historic Flooding (problem areas)	Excel	1	
				Extract from Beverley Brook Flood Alleviation Study – Historical Flooding Records	PDF	1	
	Rainfall data	All partners may hold this, data can be purchased from MET Office	✓	Rainfall data (Cheam, Jan-Feb 2007)	Excel	1	
	Anecdotal evidence	Local press, Fire and Rescue, members of the public	✓	Local Climate Impact Profile for Sutton	PDF	1	
	DG5 Register	Water and sewerage companies	✓				
Future development information	Strategic Flood Risk Assessment	Local Planning Authority	✓	Level One and Two Reports	PDF	2	SFRA should be updated when revised 2D modelling of the River Wandle is available.
	Catchment Flood Management Plan	Environment Agency	✓	Thames CFMP	PDF		
	Existing incident management plan	Local Resilience Forums					
	Future proposals	Environment Agency	✓	Richmond Green Flood Alleviation Scheme Pre-Feasibility Study	PDF	1	
				Wandle Park Pre-Feasibility Study	PDF	1	
Document & Plans	Development proposals	Local Planning Authority	✓	Core Strategy	PDF	1	
				Hackbridge Masterplan	PDF	1	
				Sutton Town Centre AAP	PDF	1	
	Drainage Area Plans	Water and sewerage companies					
Water Quality Information	Water quality information	Environment Agency					
	Continuous and intermittent discharges	Water and sewerage companies					

3.6 Level of Assessment adopted for SWMP

3.6.1 SWMPs can function at different geographical scales and therefore necessarily at differing scales of detail. Table 3-2 defines the potential levels of assessment within a SWMP. LB Sutton is preparing a SWMP for their entire administrative area and therefore this SWMP provides a second level 'Intermediate Assessment'.

Table 3-2 SWMP Study: Levels of Assessment [Defra 2010]

Level of Assessment	Appropriate Scale	Outputs
1. Strategic Assessment	Greater London	• Broad understanding of locations that are more vulnerable to surface water flooding. • Prioritised list for further assessment. • Outline maps to inform spatial and emergency planning.
2. Intermediate Assessment	Borough wide	• Identify flood hotspots which might require further analysis through detailed assessment. • Identify immediate mitigation measures which can be implemented. • Inform spatial and emergency planning.
3. Detailed Assessment	Known flooding hotspots	• Detailed assessment of cause and consequences of flooding. • Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

Strategic Assessment – Drain London Project

3.6.2 A strategic assessment has begun which is being carried out for the whole of the Greater London conurbation. In 2007 the Drain London Forum was established to bring together representatives from organisations with the information and / or responsibility for managing surface water drainage in London. The Forum has developed into a committed and effective partnership, which has delivered a study into the data holdings of all its members and recommended strategies for sharing the data among them. The membership includes representatives from Defra, The Environment Agency, The Government Office for London, Greater London Authority, London Boroughs, London Councils, London Development Agency, Thames Water, Transport for London and Network Rail.

3.6.3 The aim of Drain London is to deliver the following;

- A spatial, London-wide assessment of current and future surface water flood risk, covering flood sources, pathways and receptors.
- A London-wide, digital mapping of critical drainage pathways, including major infrastructure.

- A strategy for managing surface water going forward, that promotes sustainable land use, defines approaches for managing runoff and is reflected in other spatial plans, such as the London Plan, Opportunity Area Planning Frameworks and Local Development Frameworks.
- A tool for planners and developers to support the delivery of the strategy. The tool must identify surface water flood risk in each area, along with localised approaches to maintain or improve the level of flood risk.
- A Green Roof Fund to subsidise green roofs and walls.
- Community Flood Action Plans.
- Critical Drainage Area action plans for areas at most serious risk of flooding.

3.6.4 It is proposed to deliver the plan using a phased approach. The contract for the first tier of work was awarded in March 2010 and the project is anticipated to conclude in 2011.

3.6.5 It is recommended that LB Sutton continue to engage with the Drain London Forum as this study progresses to ensure any work completed is shared and that there is no unnecessary duplication of effort and expense, and that solutions are appraised and assessed in the context of wider flood risk management efforts in the surrounding boroughs.

Intermediate Assessment

3.6.6 As shown in Table 3-2, the intermediate assessment is applicable across a large town, city or borough. In the light of extensive and severe historical flooding and the results from the over-arching national pluvial modelling suggesting that there are 9,900 properties at risk across the Borough, it is appropriate to adopt this level of assessment to further quantify the risks.

3.6.7 The purpose of this intermediate assessment will be to further identify those parts of the borough that are likely to be at greater risk of surface water flooding and require more detailed assessment.

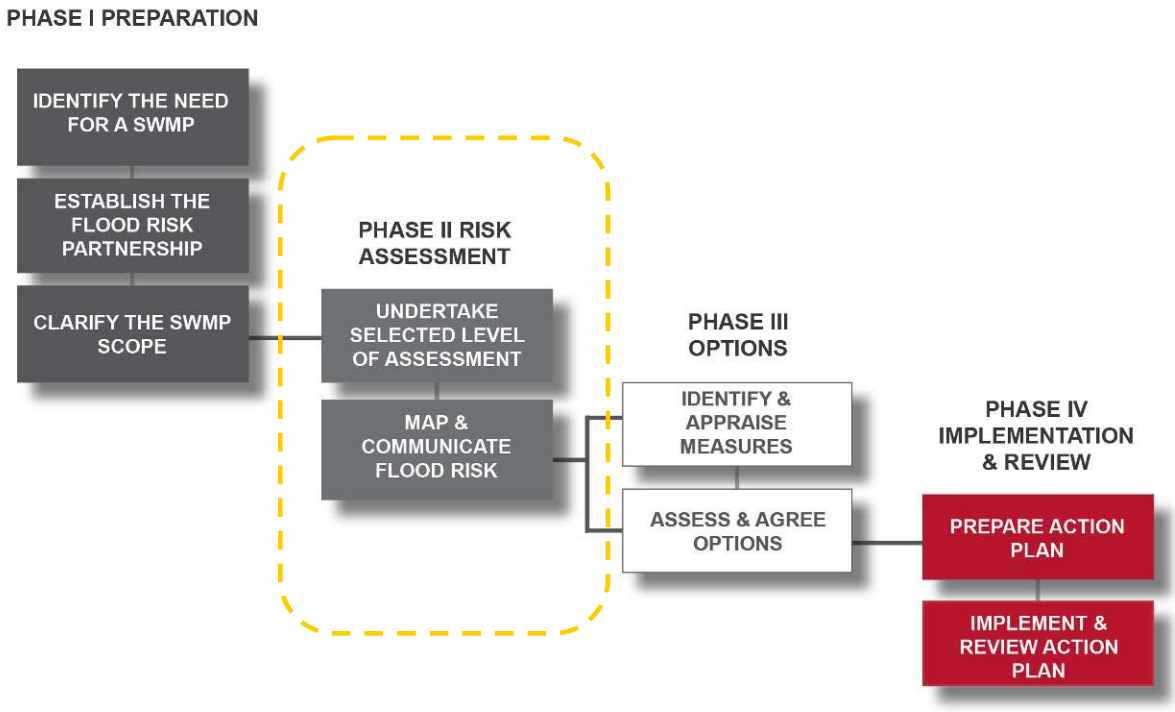
3.6.8 The outputs from this intermediate assessment should be used to update spatial and emergency planning and to identify potential mitigation measures including quick win measures which can be implemented to reduce surface water flooding. These may include improved maintenance and clearance of blockages.

Detailed Assessment

3.6.9 As stated above, the purpose of the immediate assessment is to identify those parts of the borough that are likely to require more detailed assessment to gain an improved understanding of the causes and consequences of surface water flooding, and to test the benefits and costs of mitigation measures. This is typically undertaken using modelling of the surface and subsurface drainage system.

3.6.10 It is emphasised that this level of assessment is not included within the current SWMP.

PHASE II: RISK ASSESSMENT



4 Intermediate Assessment

4.1 Preliminary Identification of Critical Drainage Areas (CDAs)

4.1.1 In September 2009, a project start-up meeting was held with LB Sutton to discuss sources of data and information available for the SWMP study and to provide an initial overview of the history of flooding throughout the borough. This information was cross-referenced with areas of potential growth in the borough in order to better define the five identified preliminary Critical Drainage Areas (CDAs). The Environment Agency refers to a Critical Drainage Area (CDA) as an area within Flood Zone 1 which has 'critical drainage issues'. Within the SWMP community, there is a 'working definition' of Critical Drainage Area (CDAs) as discrete geographic areas (usually within an urban setting) where there may be multiple and interlinked sources of flood risk and where severe weather is known to cause flooding of these areas thereby affecting people, property or local infrastructure.

4.1.2 The preliminary CDAs identified within the borough are described below:

Sutton Town Centre

4.1.3 Drainage records held by LB Sutton highlight 35 instances of flooding in the Sutton Town Centre Area. Flood risk in this location is largely caused by surface water and overland flow-paths. The Core Planning Strategy for LB Sutton identifies the need for future development and renewal of parts of the Sutton Town Centre and an Area Action Plan for the Town Centre is currently undergoing preparation. Sutton Town Centre has therefore been identified as a key area where further investigation into the mechanisms of surface water flooding is required through the application of intermediate pluvial flooding. This modelling will help to refine the flood risk information and inform future development as well as smaller areas where detailed pluvial modelling may be required.

Hackbridge

4.1.4 Hackbridge is located in the north east of the borough. The area has been earmarked in the Core Planning Strategy for substantial regeneration and development as part of the vision for it to become the UK's first sustainable suburb.

4.1.5 Hackbridge is known to have a high water table due to the presence of local springs. In addition, during periods of high flows in the River Wandle, the local surface water drainage system becomes overwhelmed leading to surface water flooding in Nightingale Close, Nightingale Road, Buckhurst Avenue, Corbet Close and Culvers Way. Hackbridge has been highlighted as an area requiring further investigation due to the complicated interaction of flood sources and mechanisms combined with demands for additional development and regeneration.

Worcester Park

4.1.6 Worcester Park, in the north west of the borough, has suffered from well documented flooding in recent years which has largely been attributed to fluvial flooding from the Beverley Brook. LB Sutton has records of flooding across the area including Beverley Gardens, Green Lane and Caverleigh Way. The flood risk partnership was keen to carry out pluvial modelling in this area in order to ascertain any additional information on the interaction between fluvial and surface water flooding mechanisms.

Wallington

4.1.7 There are no main rivers or ordinary watercourses in the Wallington area. However, Wallington has suffered from severe flooding which has been documented in both local and national press. In extreme rainfall events the local drainage system is severely overwhelmed leading to localised flooding in topographical depressions in the highways, primarily in the vicinity of Wallington Station. The flood risk partnership have been keen to further refine the limited information on flood risk in Wallington through the use of intermediate pluvial modelling.

Carshalton

4.1.8 There are a number of springs in the area surrounding Carshalton which form the headwaters of the Carshalton Branch of the River Wandle. The Environment Agency highlights the potential for flooding in this area from this watercourse. However, LB Sutton was keen to further refine information on the combined impacts of surface water and groundwater flood risk through the application of intermediate pluvial modelling and groundwater assessments.

4.2 Phase II Scope

4.2.1 The purpose of Phase II 'Intermediate Risk Assessment' is for the local flood risk partnership to further develop their understanding of the surface water flood risk in the borough and subsequently to communicate this risk to relevant parties. As defined in Section 3.2, the specific objectives of Phase II are set out below:

- Undertake suitable modelling approach to enable an intermediate assessment of surface water flood risk in the borough;
- Quantify the risks from surface water flooding through the identification of overland flow paths and areas of surface water ponding leading to an assessment of properties and infrastructure at risk;
- Map the results of the pluvial modelling;
- Communicate flood risks to relevant bodies within the local flood risk partnership; and
- Provide recommendations for detailed risk assessment if appropriate.

4.2.2 In order to achieve these objectives, the following elements of work have been undertaken:

- Review of existing data identified and collated in Phase I;
- Hydrological site investigations with a member of the drainage team at LB Sutton;
- Direct rainfall pluvial modelling;
- Review of data relating to the existing sewer system from Thames Water; and
- A borough-wide groundwater assessment.

The findings of these assessments are described in the following chapters, which consider each of the following sources of surface water flooding in turn:

- **Surface runoff**; runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing flooding (known as **pluvial flooding**);

- **Sewer flooding**[8]; flooding which occurs when the capacity of the underground network system is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters[9] as a result of wet weather or tidal conditions;

- Flooding from **small open channels and culverted urban watercourses**[10] which receive most of their flow from inside the urban area and perform an urban drainage function; and

- Overland flows resulting from **groundwater sources**.

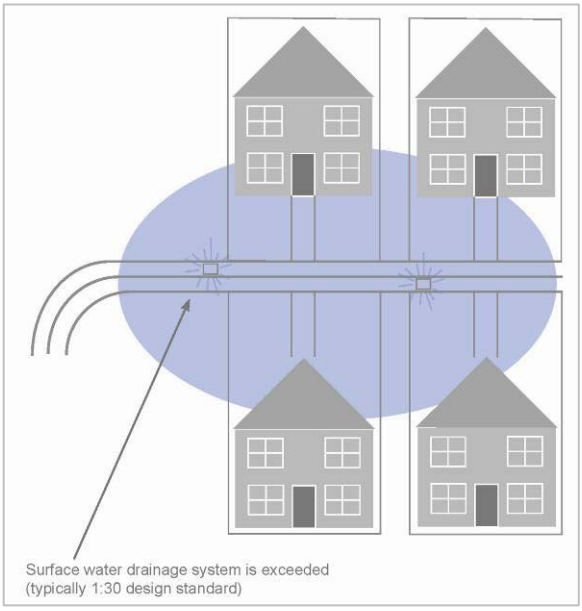
[8] Consideration of sewer flooding in 'dry weather' resulting from blockage, collapse or pumping station mechanical failure is excluded from SWMPs as this if for the sole concern of the sewage undertaker.
[9] Interactions with larger rivers and tidal waters can be important mechanisms controlling surface water flooding.
[10] These watercourses will frequently be ordinary watercourses (within the responsibility of local authorities) but may also be designated Main River (with responsibility of the Environment Agency).

5 Pluvial Flooding

5.1 Overview

5.1.1 Pluvial flooding occurs when high intensity rainfall generates runoff which flows over the surface of the ground and ponds in low lying areas. It often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with the additional flow.

Figure 5-1 Pluvial Flooding [Scott Wilson 2009]



5.1.2 LB Sutton has experienced widespread severe pluvial flooding, particularly during episodes of summer rainfall during July 2007. The summer downpours of 2008 and 2009 led to pluvial flooding and were a reminder of the fragility of local infrastructure and existing drainage system to deal with heavy rainfall.

5.2 Data / Information Review

Topography

5.2.1 The topography of the borough is shown in Figure C-01. Elevations are approximately 10m AOD in the north of the borough around the fluvial floodplains of the River Wandle, Pyl Brook and increase to 100m AOD in the south of the borough. This topography results in steep slopes within the borough, which often form ideal flow-paths for surface runoff, and subsequently pluvial flooding at lower elevations.

National Pluvial Modelling

5.2.2 The Environment Agency has undertaken pluvial modelling at a national scale and produced mapping identifying those areas susceptible to surface water flooding. The mapping relevant to LB Sutton is shown in Figure C-02.The primary purpose of this mapping is to assist Local Authorities

with emergency planning procedures and it should be noted that this national mapping has the following limitations:

- The mapping does not show the interface between the surface water network, the sewer systems and the watercourses;
- It does not show the susceptibility of individual properties to surface water flooding;
- The mapping has significant limitations for use in flat catchments.

5.2.3 This mapping provides national coverage and has been produced using a highly simplified method that excludes urban sewerage and drainage systems, excludes buildings, and uses a single rainfall event. It is noted that this mapping is intended for use by the Local Resilience Forums solely to inform emergency planning and should not be used for spatial planning decisions. In addition, the Environment Agency strongly recommend that local knowledge is applied to assess the suitability of the mapping as an indicator of surface water flooding before emergency planners make decisions based upon it.

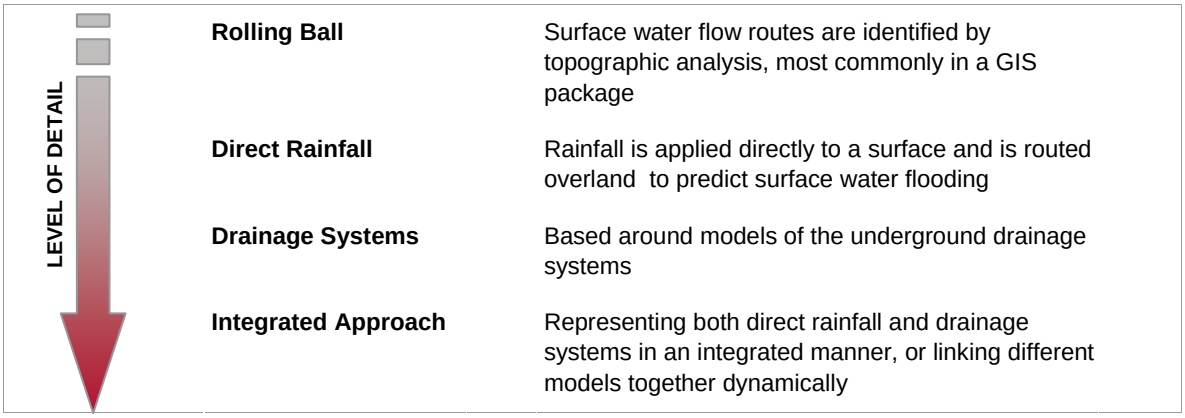
5.2.4 In the light of these recommendations, this mapping has been used purely as an initial high-level overview of pluvial flood risk across the borough which is being reviewed in conjunction with local knowledge of pluvial flooding incidents to form a platform for the intermediate risk assessment.

Borough-Wide Pluvial Modelling – Direct Rainfall Approach

5.2.5 In order to continue developing an understanding of the causes and consequences of surface water flooding in the study area, intermediate level hydraulic modelling has been undertaken for a range of rainfall event probabilities. This hydraulic modelling has been designed to provide additional information where local knowledge is lacking and forms a basis for future detailed assessments in areas identified as high risk.

5.2.6 A Direct Rainfall approach (see Figure 5-2) using TuFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and is routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond. A full methodology of the hydraulic modelling undertaken is included in Appendix E.

Figure 5-2 Levels of Pluvial Modelling [SMWP Technical Guidance March 2010]



5.2.7 Rainfall events with the following return periods have been modelled:

- 1 in 30 year event
- 1 in 50 year event
- 1 in 75 year event
- 1 in 100 year event
- 1 in 100 year event plus Climate Change (+20%)

5.2.8 ASCII grids and MapInfo TAB files have been created for all five scenarios and are in a format ready for transfer to LB Sutton for upload onto their in-house GIS system.

5.2.9 As part of this study, figures have been prepared provided covering the areas of interest within the borough for the 1 in 75 year event and 1 in 100 year event with climate change. This mapping is included in Appendix D.

5.2.10 It is anticipated that these maps should be used for facilitating the engagement of stakeholders on surface water flooding issues, to further inform spatial planning process, to inform future capital investment decisions, to inform emergency planning functions carried out by Local Resilience Forums and to identify whether critical infrastructure is at risk from surface water flooding.

5.2.11 However, the limitations of this modelling should be considered when using the information. The key points are that the intermediate modelling assumes that no water either enters the underground drainage network or infiltrates into the soil surface. In addition, the modelling does not take into account any capacity issues of the local drainage network such as surcharging of manholes which may lead to backing up and further pooling of surface water in identified critical drainage areas.

Historical Flooding & Maintenance Records

5.2.12 LB Sutton has provided records of roads and broad locations which experienced flooding during the July 2007 floods[11]. Approximately 120 locations are included in this report. These incidents have been geo-referenced and mapped over the national pluvial modelling dataset in Figure C-03.

5.2.13 In addition, a record of the highway drainage improvement works that were undertaken following the July 2007 flooding events is included in Table 5-1. This information has also been geo-referenced and presented in Figure C-03. GIS analysis has confirmed that the locations of the drainage improvement works are located in areas identified as being at risk of pluvial flooding based upon the 2D pluvial modelling completed as part of this Phase II SMWP.

Hydrological Site Inspections

5.2.14 To support this information, hydrological site inspections were undertaken on 26th December 2009 and the 4th of February 2010 with a member of the drainage team from LB Sutton to provide detailed knowledge on the sources and mechanisms of flooding at these locations as well as information regarding the improvement works that have been implemented. Site photographs were taken, and are included in this report where necessary.

[11] LB Sutton (September 2007) Report of the Chief Executive – Flooding on Friday 20th July 2007

Table 5-1 Highway Drainage Improvement Works following July 2007 floods [LBS 2007]

	Location	Highway Drainage Improvement Works
Worcester Park	Tilehurst Road	Kerbing to deflect floodwater and 3 new drainage catchment chutes
	Malden Road	Drainage alterations to improve catchment
	The Glade	2 lengths of drainage channel
	Ridge Road	2 new drainage catchment chutes
	Burleigh Road	2 new drainage catchment chutes
Sutton Town Centre	Camborne Road	3 new drainage catchment chutes
	Revell Road	60m of new drainage channel
	Chiltern Road	Kerb alterations and new drainage catchment chutes at 12 locations
	The Highway	Kern alterations and new drainage catchment chutes at 8 locations
	42 York Road	Bund across driveway to prevent property flooding
	Langley Park Road	10 new chutes and kerb inlets
	Langley Park Road (Cedar Rd to Carshalton Rd)	2 new kerb inlets and 8m of new drainage channel
	Sutton Court Road	Overflow pipe from soakaway to SW sewer
	Morland Road	5 new drainage catchment chutes
Carshalton	West Way	Bund across driveway to prevent property flooding
	31 Shirley Avenue	New drainage catchment chute
	South Avenue	New drainage catchment chute
	31 Woodmansterne Road	10m of new drainage pipe out falling to pond
	West Street Junc Festival Walk	Bund across driveway to prevent property flooding
	201 Bansted Road	27m of drainage pipe out falling to River Wandle re-laid
	104 The Causeway	20 sq m of flood damaged carriageway
	2 Downside Road	Bund across driveway to prevent property flooding
	Brookfield Avenue Junc Wrythe Lane	Flood alleviation scheme comprising bund and ditch
Hack-bridge	London Road Junc Riverside Close	Bund across driveway to prevent property flooding
	Derek Avenue	4 new drainage chutes
Wallington	59 Boundary Road	3 new drainage catchment chutes
	Wallington stn	Decanting of soakaways under the railway bridge following severe events to ensure they work to their full potential
	Boundary Road Junc Hawthorne/Brambledown/Heathdene	New drainage catchment chute
	Park Hill Road Junc Hall Road	Kerbing to deflect floodwater and 3 new drainage catchment chutes

5.3 Area Assessment – Wallington

5.3.1 Wallington is located to the east of Sutton Town Centre and does not have any main rivers within its catchment. Flooding in this location has been attributed to short, intense periods of rainfall such as that experienced in July 2007 when 44mm of rain fell in the morning of 20th July. Flooding in Wallington has attracted both local and national media attention due to the severity of flooding. LB Sutton has records of flooding affecting the highway and property on 18 streets within the Wallington area.

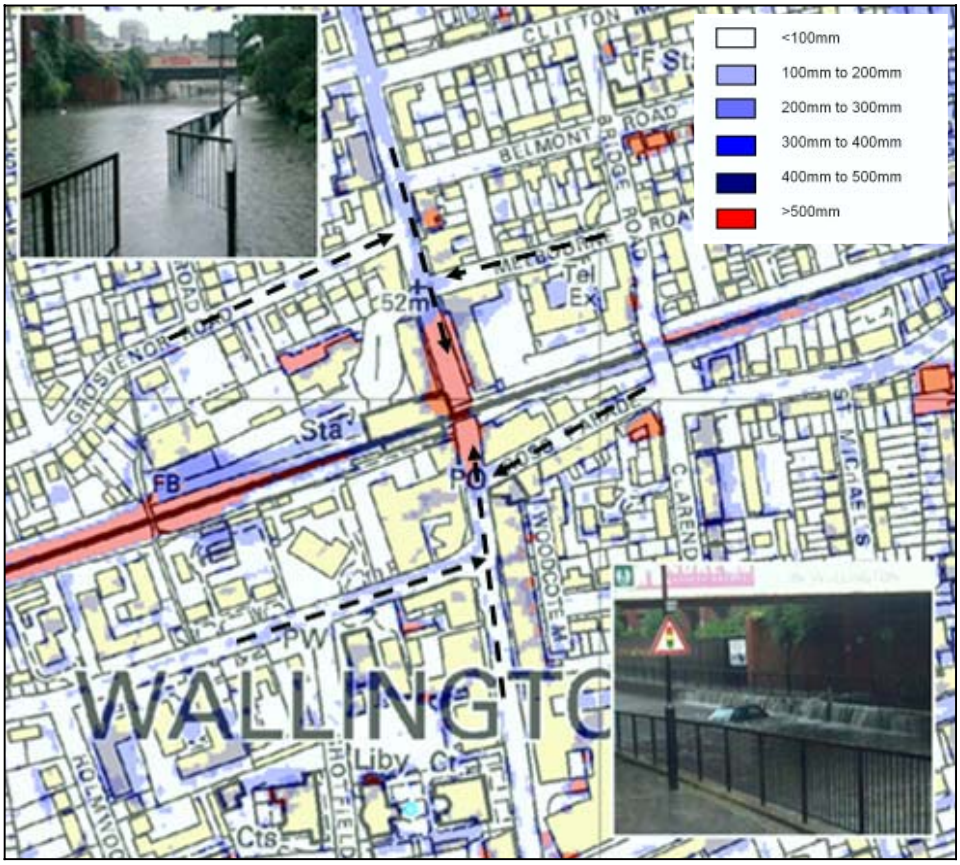
5.3.2 Pluvial modelling has been used to pin point 'hot spots' within the Wallington CDA where surface water flood risk may be a greater potential risk being:

- Wallington Station
- Demesne Road railway crossing
- Beddington Gardens

Wallington Station

5.3.3 Surface water flooding on Manor Road, close to Wallington Station, is a recurring problem. It is primarily caused by a highway underpass which was built to facilitate headroom under the railway parapet. During extreme rainfall events, surface water flows along the highway from the surrounding area towards the hollow (see Figure 5-3 below). Following a rainfall event, flood water drains away within a few hours.

Figure 5-3 Wallington Station Road Bridge



5.3.4 Pluvial modelling of Wallington illustrated in Figure D-12 highlights that flooding in this area during a 1 in 100 year event including climate change would reach a depth of approximately 2.5m.

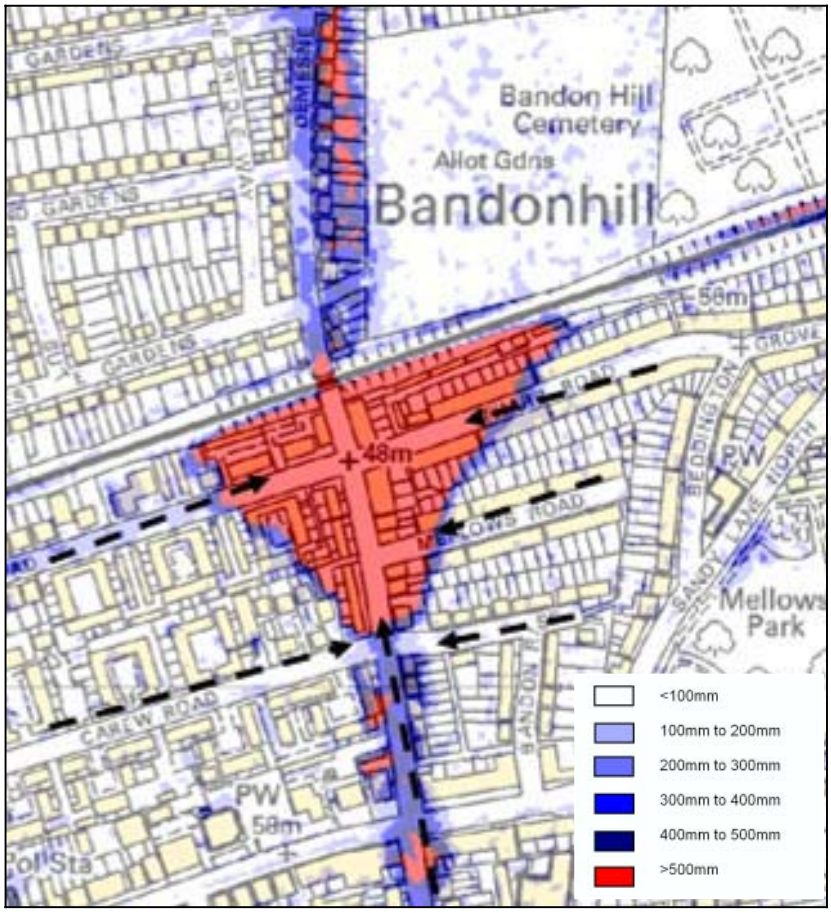
5.3.5 At the low point in the highway are two 15m deep soakaways. The soakaways have an overflow which connects to the foul water system but reportedly in severe precipitation events, both systems can be inundated and surface water flooding occurs as a result. In addition, the piped surface water system in this area includes carrier pipes contained in the raised footpath, during an extreme event these pipes reportedly surcharge and additional water flows off the pavement into the hollow under the bridge.

5.3.6 The soakaways are dewatered following severe events to ensure that they have sufficient capacity and perform to their full potential. There are no properties at this location affected by flooding, however, surface water flooding causes severe disruption to transport infrastructure and danger to life for those stranded in cars.

Demesne Road railway crossing

5.3.7 Pluvial modelling has highlighted a potential surface water flow path to the east of Wallington Station at Demesne Road. Pluvial modelling illustrates that in the 1 in 100 year event including climate change, surface water would flow along Demesne Road in a northerly direction towards the railway embankment. Ground levels suggest that water would pool to the south of the railway line in the vicinity of Tharp Road and Mellows Road reaching a potential depth of approximately 3.5m behind the embankment (see Figure 5-4 below).

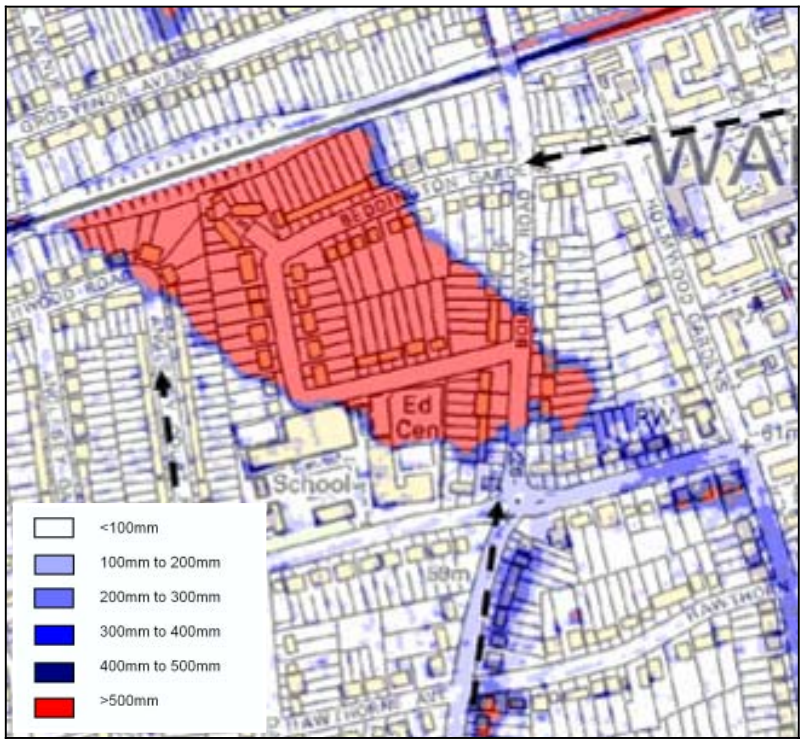
Figure 5-4 Pluvial modelling at Demesne Road



Beddington Gardens

5.3.8 Pluvial modelling has highlighted a potential surface water flow path to the west of Wallington Station at Beddington Gardens. Pluvial modelling suggests that in the 1 in 100 year + climate change storm event, surface water could flow north along Park Hill Road and Boundary Road towards Beddington Gardens where surface water would pool upstream of the railway embankment to a potential depth of 4m as illustrated in Figure 5-5 below.

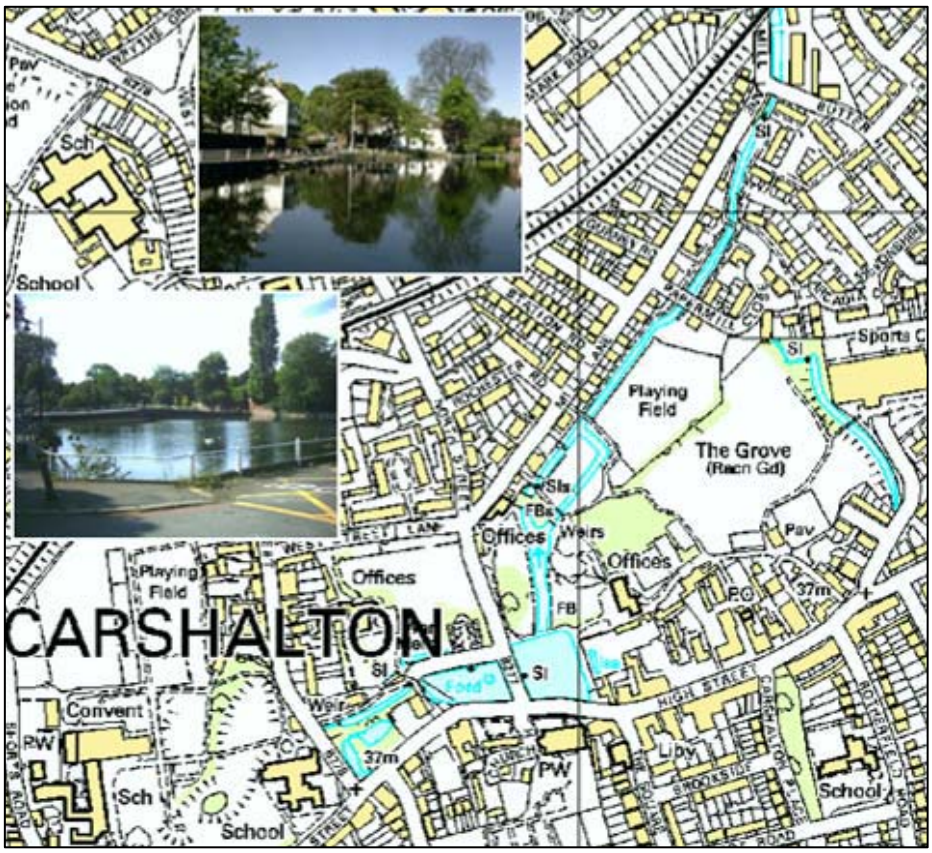
Figure 5-5 Pluvial modelling at Beddington Gardens



5.4 Area Assessment – Carshalton

5.4.1 Carshalton has been highlighted as a critical drainage area as there are a number of springs in the local area which forms the headwaters of the Carshalton Branch of the River Wandle. In addition, the centre of Carshalton is dominated by a number of ponds as illustrated in Figure 5-6. LB Sutton records show that during the July 2007 flood event, properties on 30 roads within Carshalton were affected by flooding.

Figure 5-6 Carshalton Ponds



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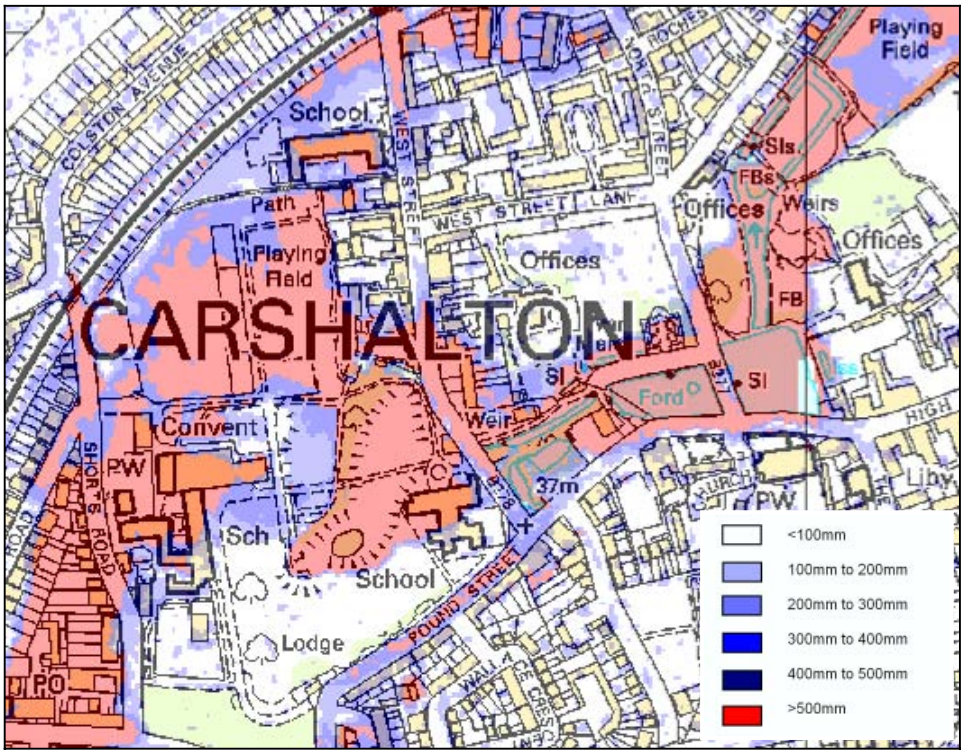
5.4.2 Pluvial modelling illustrates that surface water flood risk in this area is largely constrained to lower ground associated with the Wandle headwaters as illustrated in Figure D-10.

5.4.3 Two flood 'hot spots' have been highlighted being the centre of Carshalton and the Mill Lane crossing of the railway line. These areas were chosen for further analysis as it was considered that flooding at these two locations would cause significant disruption to the local area.

Carshalton Centre

5.4.4 Pluvial modelling of Carshalton Centre (illustrated in Figure 5-7) shows that there is a risk that West Street Lane and the surrounding area could become an island surrounded by floodwater in the 1 in 100 year + climate change storm event. Modelling also shows that while the velocity of the water is not high, the ponding depth could reach 0.5m. Pluvial 2D predictive modelling indicates that water will flow from west to east following the path of the watercourse.

Figure 5-7 Pluvial modelling at Carshalton Centre



Mill Lane Carshalton

5.4.5 Pluvial modelling shows that during the 1 in 100 year event including an allowance for climate change the Mill Lane area of Carshalton becomes impassable to vehicles with depths of water of up to 0.5m. At this location the watercourse flows adjacent to the highway and any surface water flooding will be compounded by potential fluvial flooding.

5.5 Area Assessment – Worcester Park

5.5.1 Flooding in Worcester Park is largely caused by fluvial flooding from the Beverley Brook which flows north along the western boundary of the Borough. Records of flooding of Green Lane, Caverleigh Way and Browning Avenue date back to the 1960's and occur when water levels in the brook rise and overtop along much of the length which runs parallel to Green Lane. The Environment Agency previously investigated the feasibility of a flood alleviation scheme at this location, but concluded that there was insufficient economic justification to invest in a scheme here. The Council may re-evaluate flood risk management options in this location in light of the Flood Risk Regulations and the outputs from this study.

5.5.2 Fluvial flooding and elevated river levels in this location has a limiting effect on local surface water drainage as surface water is often unable to discharge to the watercourse during periods of high water level leading to localised surcharging and backing up of water through the surface water drainage system.

5.5.3 Pluvial modelling results identify surface water flood risk along the Beverley Brook corridor attributed to lower ground levels associated with this area. Flow data identifies that during a

surface water flood event, water would flow onto Green Lane from the south and would pool under the Central Road railway crossing at Worcester Park rail station.

5.5.4 Pluvial modelling also highlights that there are potential flooding hot spots away from the Beverley Brook in locations such as Buckland Way.

5.6 Area Assessment – Hackbridge

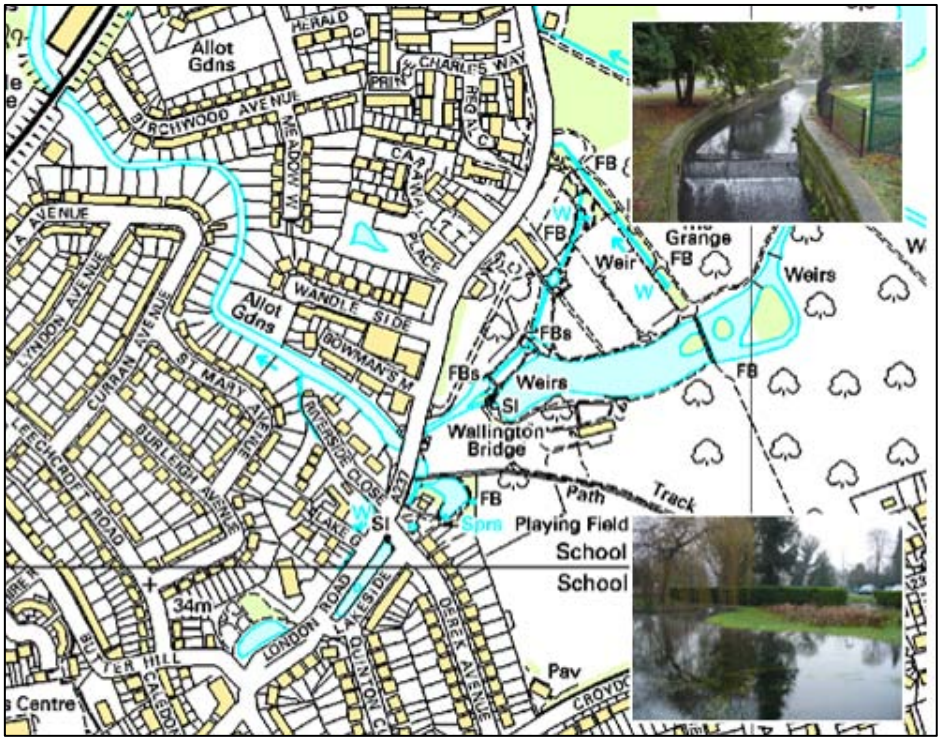
5.6.1 Flooding in Hackbridge is caused by a number of sources including pluvial, groundwater and fluvial. The Carshalton and Waddon branches of the Wandle combine at Hackbridge and flow in a north westerly direction through Mitcham. The watercourse is fed by a series of springs in the area and receives surface water drainage throughout the catchment.

5.6.2 Fluvial flood risk is discussed in more detail in the London Borough of Sutton Strategic Flood Risk Assessment. When the river is in flood, surface water drainage systems often become surcharged, preventing the outfall of storm water which can then back-up through the system and cause flooding elsewhere in the catchment.

5.6.3 Pluvial modelling highlights that there is risk of surface water flooding to a depth of 0.5m across large sections of Hackbridge (Figures D-13 – D-16). This is largely due to the shallow gradient and tendency for water to pond on the ground surface.

5.6.4 Pluvial modelling undertaken as part of this study does not take account of groundwater (this is discussed further in Section 8). In Hackbridge, the water table is only 1m below ground level in places and there are a number of spring fed ponds, as illustrated in Figure 5-8 below. If the groundwater table rises to any degree there is a large risk of groundwater flooding adding to the existing surface water flooding potential.

Figure 5-8 Surface water features in Hackbridge



5.6.5 Discussions with the Council drainage engineer highlighted some works which have been completed at Riverside Close where surface water from the highway flowed to the natural low point at Riverside Close. The LB Sutton drainage engineer organised for a bund to be built at the end of Riverside Close (Figure 5-9) and a swale (Figure 5-10) in the kerbside to channel water back to the river. There have been no reports of surface water flooding at this location following the completion of these works.

Figure 5-9 Bund at the end of Riverside Close

Figure 5-10 Swale at Riverside Close

5.7 Area Assessment – Sutton Town Centre

5.7.1 Sutton Town Centre is located in a natural depression in the local topography where surface water collects and naturally flows north towards the Pyl Brook. The LB Sutton has record of flooding along 33 roads in the Sutton Town Centre area following the flood event of 2007. Pluvial modelling shows that surface water flood risk is greater in areas to the south of the town centre near to Cedar Road

Sutton Junction

5.7.2 Pluvial modelling to the south of the Town Centre suggests that surface water may pool in the Cedar Road/Wellesley Road area at Sutton Junction. This is supported by the local drainage engineer who reports that there is localised surface water flooding at this location as water pools in the road when the capacity of the road drainage system is exceeded. Reportedly, surface water flows from the highway, onto the pavement and affects local property. A further issue reported is the design of the surface water sewer at this location which passes through a 90 degree bend causing water to surcharge onto the highway. It is understood that the Council has made capital investments in this area and have built extra gulleys and soakaways to help alleviate the problem.

5.7.3 Moorland Road has suffered from surface water flooding in the past as the western end of the road is located in a hollow. Reportedly surface water flows along Langley Park Road to Moorland Road where property has been flooded. The original piped surface water drainage system carried surface water to the east along Moorland Road to connect to the main carrier pipe in Carshalton Road. Following surface water flooding, LB Sutton has completed remediation works in this area to include the addition of new stand alone soakaways and a gulley system in Moorlands Road which is linked into the surface water drainage system in Langley Park Road. In addition, new double gulleys have been located on Langley Park Road to 'catch' as much surface water as possible before it flows into Moorland Road. Pluvial modelling highlights the potential for water to

pool in the Moorland Road area which could reach a depth of 0.5m in places (see Figure 5-11 below).

Figure 5-11 Pluvial modelling at Sutton Junction

Palmerston Road/Turnpike Lane

5.7.4 Pluvial modelling shows a potential flooding hotspot north of Sutton Junction at Turnpike Lane and Palmerston Road. The Sutton Drain Engineer did not highlight this area as a high flood risk area and we understand that there have been now drainage improvement works in this area.

Stayton Road at railway crossing

5.7.5 Flooding has been recorded by LB Sutton as an issue on Stayton Road following the 2007 flood event. Flood water continues to flow in a northerly direction, to the east of Sutton Town centre before reaching the railway line crossing at Stayton Road. Pluvial modelling highlights that the road bridge beneath the railway line may act as a constriction to flood waters which then pool behind the railway embankment in the Sorrento Road area.

Stayton Road at Anton Crescent

Pluvial modelling also highlights an area of potential flooding to the north of the railway embankment at Stayton Road (see

5.7.6 Figure 5-12 below). Anton Crescent is a flood risk storage area operated by the Environment Agency and is designed to reduce the peak storm flows from the Pyl Brook through attenuation. The flood storage area is underlain by clay and has a pond which holds water all year round. The flood storage has an area of approximately 1.5ha.

Figure 5-12 Pluvial modelling Anton Crescent

5.8 Other Areas of Flooding

Trafalgar Avenue, North Cheam

5.8.1 Flooding in Trafalgar Avenue is largely attributed to the Pyl Brook which flows in an open channel parallel to Trafalgar Avenue. During periods of heavy rain water levels in the brook rise and overtop the banks flowing onto Trafalgar Avenue. Figure 5-13 below shows the location of houses in relation to the Pyl Brook.

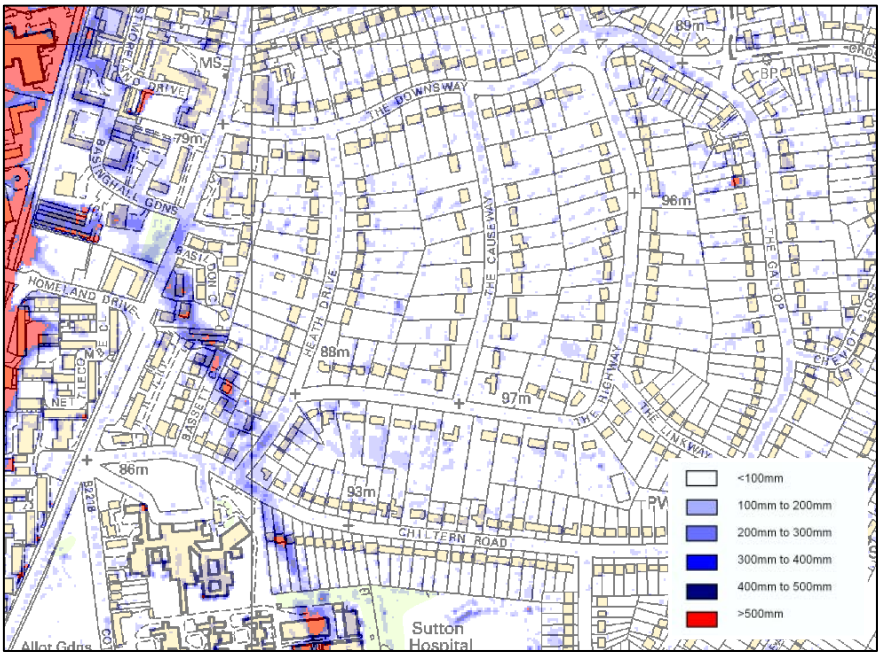
Figure 5-13 Trafalgar Avenue

The Gallop / The Linkway / Heath Drive / Carshalton Beeches

5.8.2 Hydrological site inspections with LB Sutton drainage engineer highlighted one further area where there is a history of surface water flooding to the south west of Carshalton Beeches. The area at risk includes The Gallop, The Linkway, Heath Drive and Chiltern Road.

5.8.3 Flooding in this area is caused by the local topography and large catchment areas created by the surrounding roads. During high intensity rainfall events, the velocity of the overland flow over the ground surface often prevents it from entering the gulley pots. On site records verify the pluvial modelling (Figure 5-14 below) which illustrate that water will collect in the Heath Drive area which is located at a low point in the local catchment.

Figure 5-14 Pluvial modelling at Carshalton Beeches



5.8.4 LB Sutton has invested in the local drainage along these four highways by incorporating extra gulleys with 'cut ins' along local roads as illustrated in the photos below. These extra gulley's reduce the impact of leaf litter on the drainage system and act to slow water, increasing the volume of water entering the gulley pots. In addition to these measures, LB Sutton has incorporated a 10m deep 2.5m wide soakaway at Heath Drive.

Revell Road

5.8.5 To the south west of the Sutton town centre, flooding has been reported in Cecil Road and Revell Road. Surface water at this location flows along Belmont rise and east along Cheam Road to form a pool in a low point in the highway at Revell Road (Figure 5-15 below). The council have installed linear drainage gulley's to capture as much surface water drainage as possible. It should be noted that this solution is reliant on the Thames Water surface water drainage system which in this location is served by a 600mm diameter pipe. If surface water flooding continues to be an issue in this location, there may be potential to install soakaways.

Figure 5-15 Pluvial modelling at Revell Road

5.8.6 Recommendations for further work are discussed in Chapter 10.

6 Sewer Flooding

6.1 Overview

6.1.1 During heavy rainfall, flooding from sewer system may occur if:

- The rainfall event exceeds the capacity of the sewer system / drainage system;
- The system becomes blocked by debris or sediment;
- The system surcharges due to high water levels in rivers.

6.1.2 Figure 6.1 below illustrates the impact of sewer flooding with water surcharging out of manholes flooding the surrounding area.

Figure 6-1 Rainfall exceeding capacity of sewer system at Wallington Station

6.2 Responsibility

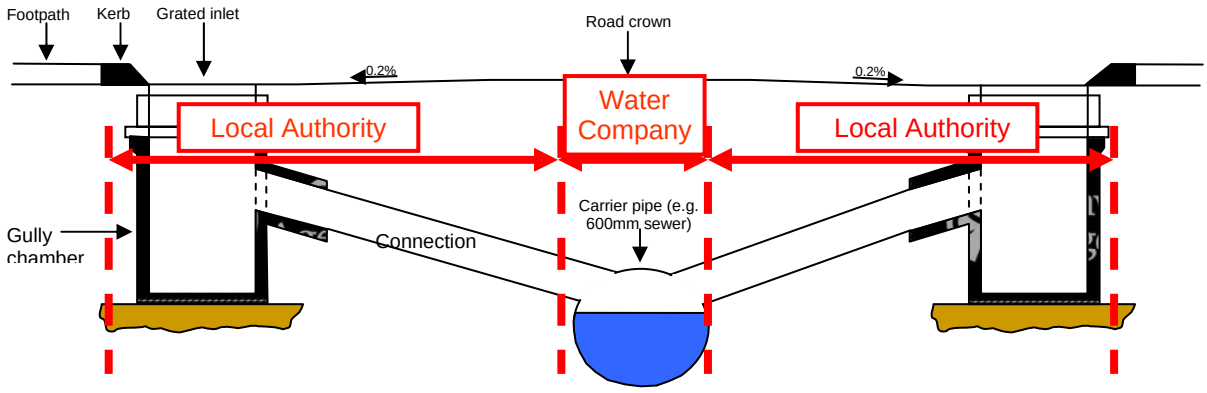
6.2.1 In order to clearly identify problems and solutions, it is important to first outline the responsibilities of different organisations with respect to drainage infrastructure. The responsible parties are primarily as follows:

- Local Authority
- Water Utility
- Transport for London

6.2.2 As illustrated in Figure 6-2, LB Sutton, as the Highways Authority is responsible for maintaining an effective highway drainage system including kerbs, road gulley's and the pipes which connect the gulley's to the trunk sewers and soakaways. The sewerage undertaker, in this case Thames Water is responsible for maintaining the trunk sewers. In addition, Transport for London (TfL) is responsible for the drainage systems on the major red routes in the borough which include the A232, A217, A237, A2043 and A2022.

6.2.3 Sewer systems are typically designed and constructed to accommodate rainfall events with a 1 in 30 year return period or less. Therefore, rainfall events with a return period of frequency greater than 1 in 30 years would be expected to result in surcharging of some of the sewer system.

Figure 6-2 Surface Water Drainage Responsibility



6.3 Data / Information Review

DG5 Register

6.3.1 Sewer flooding was identified in the local Strategic Flood Risk Assessment (Scott Wilson Ltd 2008) using data from the Thames Water DG5. This database details the total number of flood incidents that have affected properties both externally and internally over the last 10 years and is presented in Figure C-05.

6.3.2 The DG5 dataset was only provided on a five-digit postcode area, which makes it difficult to determine more precisely where sewer flooding problems may have occurred. In addition, Thames Water focus their efforts on removing properties from the DG5 register, and therefore this dataset may no longer accurately represent those properties which are currently at risk.

Hydrological Site Inspections

6.3.3 Records of sewer flooding experienced during the floods of July 2007 have been supplied by LB Sutton drainage department[12]. These have been highlighted on Figure C-05. Site inspections of key sewer flooding sites have been undertaken and are detailed below:

Wallington Station

6.3.4 Flooding at Wallington Station Road Bridge is due to a combination of factors including the capacity of the local drainage network. The drainage system at this location is served by two 15m deep soak-away located in the hollow underneath Wallington Road Bridge. In addition, the soakaways have an overflow which connects to the foul water system. The piped surface water system in this location is located in the raised footway, in extreme events these systems are surcharged and water flows over the pavement into the hollow under the bridge as illustrated in Figure 6-3.

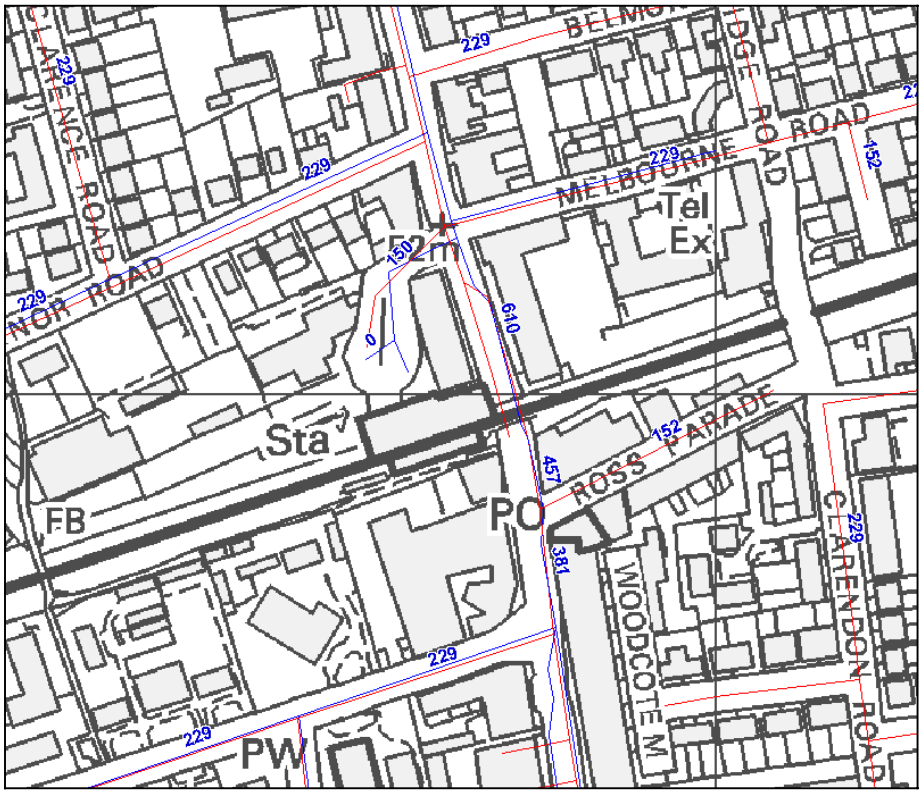
[12] LB Sutton (September 2007) Report of the Chief Executive – Flooding on Friday 20th July 2007

Figure 6-3 Surcharging of surface water system at Wallington Station

Source: www.yourlocalguardian.co.uk

6.3.5 Reference has been made to Thames Water drainage network plans which highlight the size of pipes in the local drainage network. An extract of the drainage plan is included in Figure 6-4 and shows that underneath the railway bridge the surface water drainage system in Manor Road is 610mm in diameter.

Figure 6-4 Thames Water Drainage Network Plan Wallington Bridge



Sutton Town Centre - Cedar Road

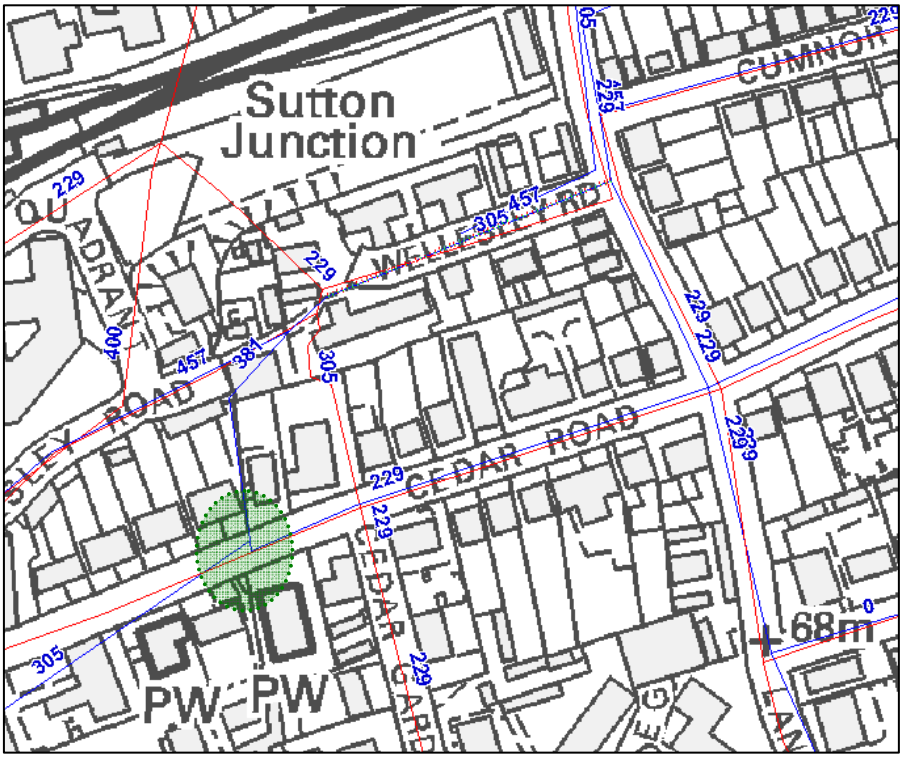
6.3.6 LB Sutton Sewer flooding records from July 2007 have highlighted Cedar Road as an area susceptible to sewer flooding.

6.3.7 The local drainage engineer has highlighted that water pools in Cedar Road when the capacity of the road drainage system is exceeded. Surface water then flows from the highway onto the pavement and into local property. A further issue is the design of the surface water sewer at this location which passes through a 90° bend causing water to surcharge onto the highway.

6.3.8 The Council has made investments in this area and have built extra gulleys and a soakaway to help alleviate the problem.

6.3.9 The Thames Water network plan illustrated in Figure 6-5 shows that the surface water system is served by a 305 and 229mm dia. pipe on Cedar Road. Thames Water has not provided details of capacity at this point. The 90° bend is highlighted in Figure 6-5.

Figure 6-5 Thames Water Drainage Network Plan Cedar Road



Hackbridge

6.3.10 Hackbridge is highlighted on the Thames Water DG5 register as having 1-2 reported sewer flooding incidents over the last 10 years.

6.3.11 Surface water drainage is difficult to manage in the Hackbridge area due to shallow gradients combined with high ground water table, local springs and the River Wandle.

6.3.12 LB Sutton has reported sewer flooding on Nightingale Close which is caused by surcharging of the surface water drainage outfall to the River Wandle which causes backing up of floodwater into Nightingale Close.

Figure 6-6 Surface Water drainage outfall, River Wandle

6.3.13 LB Sutton also has records of sewer flooding in Hackbridge on Wood Street, Orchard Avenue, Eindhoven close, Phillips Close, and Manor Road.

Beddington Gardens – Wallington

6.3.14 Pluvial modelling has highlighted a potential flooding hotspot in Beddington Gardens. Reference to Thames Water drainage network plans suggests that the local drainage system crosses the railway line in the north-west corner of Beddington Gardens. Investigations should be undertaken to make sure that this connection is working to its full potential to reduce the risk of flooding in this location in the future.

Figure 6-7 Thames Water Drainage Network Plan Beddington Gardens

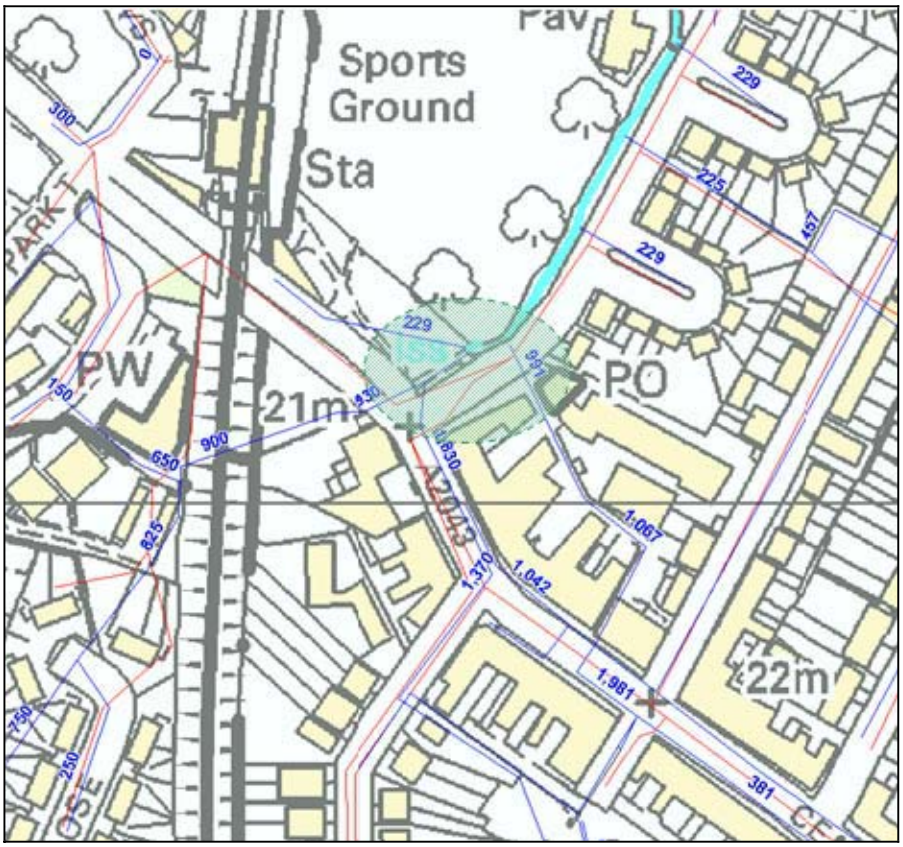
Worcester Park

6.3.15 The Beverley Brook enters a section of open channel downstream of the A2043 Central Road. At this point (illustrated in Figure 6-8) Thames Water network plans highlight 4 outfalls entering the channel which range in diameters of 229mm, 930mm, 991mm and 1,830mm.

6.3.16 These are large outfalls and there may be potential to look into the possibility of reducing the volume of water out falling, or reducing the catchment response time by attenuating water in the catchment upstream before out falling to the Beverley Brook at this point. It should be noted that the system may be surcharged during periods of high flow in the Beverley Brook which could lead to flooding upstream.

6.3.17 Detailed modelling would be required to identify potential solutions. Within the network, hard engineering solutions would be required. Other potential options may include widening the brook and creating a balancing pond.

Figure 6-8 Thames Water Drainage Network Plan Worcester Park



Trafalgar Avenue

6.3.18 Reference has been made to Thames Water network plan which shows that the largest pipe out falling to the Pyl Brook at this location is a 457mm flowing from the south west. Work with the Environment Agency is on-going in this area with regard to a potential flood alleviation scheme. The Council have also liaised with Thames Water to run a capacity check on the surface water sewers in this location.

6.3.19 Recommendations for further work are discussed in Chapter 10.

7 Small Open-Channel & Culverted Watercourses

7.1 Overview

7.1.1 SWMPs should consider the risk of flooding from small open channels and culverted watercourses in the study area. These channels and watercourses receive the majority of their flow from inside the urban area and perform an urban drainage function.

7.2 Data / Information Review

Main Rivers

Table 7-1 Main Rivers in LB Sutton

Watercourse	Classification	Owner / Maintainer
River Wandle	Main River	Environment Agency
Beverley Brook	Main River	Environment Agency
Pyl Brook (Main Branch), tributary of the Beverley Brook	Main River	Environment Agency
Pyl Brook (East Branch), tributary of the Beverley Brook	Main River	Environment Agency

7.2.1 The Environment Agency has responsibility over flooding from designated Main Rivers and flooding from this source has been further assessed as part of the previously completed Level 1 and 2 Strategic Flood Risk Assessments for LB Sutton.

7.2.2 It is understood that the Environment Agency is currently preparing updated 2D hydraulic modelling for the River Wandle and its tributaries. This modelling will produce new information regarding flood outlines, flood depths and flood velocities in the borough. It is recommended that the SFRA is updated in-line with these new flood outlines when they become available.

7.2.3 We have not assessed the affects of Main River flooding as part of this study.

Ordinary Watercourses

7.2.4 As part of this study, no information has been provided by LB Sutton regarding ordinary watercourses in the study area. A request has been submitted to the Environment Agency for the Detailed River Network (DRN). To date, no data regarding the detailed river network has been received by the Environment Agency.

7.2.5 As a result, considerably little is known about ordinary watercourses in the study area.

7.2.6 Recommendations for further work are discussed in Chapter 10.

8 Groundwater

8.1 Background

8.1.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from abnormal springs. This tends to occur after much longer periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers[13], although increasingly it is also being associated with more localised floodplain sands and gravels.

8.1.2 Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. When groundwater flooding occurs, basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

8.1.3 The following sections outline the geology and hydrogeology in the London Borough of Sutton study area. From this analysis:

- Potential groundwater flooding mechanisms are identified;
- Evidence for groundwater flooding is discussed;
- A map of potential groundwater flood risk is presented; and
- Recommendations for a more detailed study are provided.

8.2 Geology

8.2.1 Figure C7 in Appendix C provides geological information for the London Borough of Sutton and the surrounding area. Figures 8-2 and 8-3 provide geological cross sections for the study area and these have been used to improve the conceptual understanding of the area.

Solid Geology

8.2.2 The solid Geology of the area comprises the Upper Chalk[14], which in turn is overlain by the Thanet Sand Formation (fine grained sand), Lambeth Group (clay with beds of sand) and the London Clay. The Harwich Formation which outcrops to the east of the Council area, between the London Clay and the Lambeth Group, is not present within the Council area.

8.2.3 The Upper Chalk of the North Downs outcrops in the southern part of the Council area and is around 200 m thick. The Chalk dips to the north so that in the northern part of the Council area, the younger Thanet Sand Formation, Lambeth Group and London Clay units dominate the outcrop geology.

8.2.4 The feather edge of the Thanet Sand Formation and Lambeth Group runs broadly west-east through Sutton, and as demonstrated by Figure C8, the units thicken northwards reaching up to

[13] Aquifers allow significant groundwater movement
[14] According to new nomenclature for the Chalk, the term 'Upper Chalk' is no longer in formal use, and the unit has been split into several formations including the 'Lewes Nodular Formation', 'Seaford Chalk Formation', 'Newhaven Chalk Formation' and 'Culver Chalk Formation'. As these units are undifferentiated on the British Geological Survey map for the Sutton area, and for ease of reporting, the term 'Upper Chalk' is retained.

around 10 m and 20 m, respectively. The London Clay Formation also thickens to the north and is up to around 75 m in the northern part of the Council area (Figures 8-2 and 8-3).

Drift Geology

8.2.5 In the majority of the study area, Drift (recent) deposits are not present. However, there are significant Hackney Gravel River Terrace Deposits (gravel, sandy and clayey in part) in the north eastern part of the Council area and smaller deposits of Head and Clay with Flints in the central and southern part of the Council area, which overlie the North Downs Chalk. In the northern Council area there are also ribbons of Alluvium (Clay, silt, sand and gravel) within the River Wandle and Pyl Brook tributary valleys.

8.3 Hydrogeology

8.3.1 The hydrogeological significance of the various geological units within the study area is provided in Table 8-1.

Table 8-1 Geological Units in the Study Area and Hydrogeological Significance

Geological Unit		Hydrogeological Significance
Drift Geology	Hackney Gravel River Terrace Deposits	Variable (but probably an aquifer)
	Head	Variable (but probably an aquitard)
	Clay with Flints	Aquitard
Solid Geology	London Clay	Aquiclude
	Lambeth Group	Aquifer
	Thanet Sand Formation	
	Upper Chalk	Aquifer

'Aquifer' = allows significant groundwater movement
'Aquitard' - allows some groundwater movement
'Aquiclude' - does not allow groundwater movement

Solid Geology

8.3.2 The London Clay is an aquiclude and does not permit groundwater flow. The physical properties for minor aquifers in England and Wales (Allen et al., 1997) suggests 'The Thanet Sand Formation, Lambeth Group and the Harwich Formation are often considered as a single groundwater unit, known as the 'Basal Sands' aquifer, which is in hydraulic continuity with the Chalk…..in the 19th Century, water supplies to London were obtained from these beds, but in the early 20th Century this practice was abandoned almost entirely in favour of deeper bores into the Chalk'. Therefore the 'Basal Sands' may be considered as an aquifer (aquifers allow groundwater flow).

8.3.3 The underlying Upper Chalk is classified as a principal aquifer and in this region is thought to be in hydraulic continuity with the overlying 'Basal Sands' aquifer.

Drift Geology

8.3.4 The Hackney Gravel River Terrace Deposits are likely to act as a minor aquifer and where they overlie the London Clay aquiclude, it is likely that perched groundwater tables exist. The role of

Head deposits is uncertain and is likely to be variable, although they probably allow some groundwater flow.

Public Water Supply Abstractions

8.3.5 There are 22 Chalk groundwater abstraction boreholes within the administrative boundary that are used for public water supply. However, for confidentiality reasons the locations of these cannot be provided.

8.4 Groundwater Levels

Data Collation

8.4.1 Groundwater levels and borehole logs have been obtained for the study area and further details are provided in Table 8-2.

Table 8-2 Sources of water level and geological data

Source	Data and Comment
Water Company	Geological data and locations of abstraction boreholes
Environment Agency	Observation borehole locations and associated water levels, construction and geological details
British Geological Survey	69 borehole logs to confirm geology and create cross sections

Chalk Groundwater Levels

8.4.2 Figure C7 (Appendix C) shows a number of groundwater spring locations identified by Gerry McLaughlin (Principal Drainage Engineer for the London Borough of Sutton) during a site visit on the 5 February 2010. These originate where the Chalk groundwater level intercepts ground level and additional details are provided in Table 8-3. The presence of springs indicates that, at least in some areas, groundwater levels are near to ground surface.

8.4.3 The Chalk groundwater level data obtained from the Environment Agency monitoring network has been processed. Groundwater levels were generally at their highest in January 2001, although it is noted that significant peak was also observed in March 1995.

8.4.4 Groundwater level hydrographs for monitoring boreholes TQ26/143A and TQ26/22 are presented in Figure C7 to demonstrate the type of data available. Groundwater abstraction data has been requested from the water company and this could be used to interpret the impact of abstraction on groundwater level fluctuations, as part of a more detailed study.

8.4.5 Groundwater levels from the full set of observation boreholes have been used to generate groundwater level contours for January 2001 and these are presented within Figure C10.

Table 8-3 Spring details provided by Sutton Borough Council or recorded during the site visit

Spring Name	NGR	No*	Comment
Carshalton Upper Pool	TQ 2788 6456	1	Pools have been concrete lined so that when groundwater levels are low, the water in the pools does not drain into the Chalk aquifer. However, the pools have been designed so that when groundwater levels are close to or at ground level, groundwater can discharge into the pools via concrete plugs within the pool or via overflow channels at the edge of the pools.
Carshalton Lower Pool	TQ 2800 6457	2	
Lady Margaret's Pool	TQ 2779 6451	3	Ephemeral spring which flows into Carshalton Upper Pool during times of high groundwater table
Grotto Canal	TQ 2827 6410	4	Ephemeral spring which flows into the River Wandle during times of high groundwater levels
Un-named Spring	TQ 2874 6509	5	Springs visible at base of pool which overflows and is channelled into the nearby River Wandle.
Hogg Pitt	TQ 2814 6417	6	Ephemeral spring which occurs in a man made pit. Groundwater flows into the Carshalton Lower Pool during times of high groundwater levels via a culvert.
Note:*Number identified on Figure C10			

River Terrace Gravels Groundwater Levels

8.4.6 The River Terrace Gravels form a perched aquifer over the London Clay aquiclude. The Environment Agency does not monitor groundwater levels in the river terrace gravels. However, borehole logs have been collated from the British Geological Survey and these often provide details of water strikes. The boreholes were drilled in different years (i.e. groundwater contours cannot be constructed), although comments on groundwater levels can provide an indication of depth to groundwater. Figure C11 provides a summary of the data obtained. It is clear that these drift deposits are water bearing in a number of locations and the groundwater table is shallow (between 0.5 m and 3.3 m below ground level).

8.5 Groundwater Flooding Mechanisms

8.5.1 Based on the hydrogeological conceptual understanding of the study area, there are four key groundwater flooding mechanisms that may exist:

- Chalk catchments in the south: Groundwater flooding is often associated with Chalk catchments, which allow groundwater levels to rise to the near surface through permeable subsoil following long periods of wet weather and / or reductions in historic abstractions. The London Basin has historically been heavily abstracted, lowering groundwater levels in both the Chalk and the 'Basal Sands'. However, since the '*mid 1960's, declining abstraction has resulted in the water level in the Chalk / Basal Sands aquifer rising at a rate of up to 3 m per year*' (Allen et al., 1997). Therefore, depending on abstraction regimes and the presence and thickness of the London Clay aquiclude, there may be a risk of groundwater flooding at basement level or ground level.
- River Terrace deposits in the northeast: Groundwater flooding can also be associated with substantial River Terrace and Head Drift deposits, where they are in hydraulic continuity with surface water courses. Stream levels may rise following high rainfall events but still

remain “in-bank”, and this can trigger a rise in groundwater levels in the associated Drift deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements, which have been constructed within the Drift deposits. For this type of flooding to occur, the Drift deposits must behave as aquifers.

- River Terrace deposits in the northeast: A third mechanism for groundwater flooding is also associated with substantial Drift deposits, but occurs where they are not hydraulically connected to surface water courses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains.
- Various locations: The forth mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this ‘made ground’ is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements. However, this should probably be regarded as a local drainage issue as opposed to groundwater flooding. Areas mapped by the BGS as containing made ground are shown in Figure C7.

8.6 Evidence of Groundwater Flooding – Method of Assessment

8.6.1 Figures C7 and C10 show the location of a number of groundwater flooding incidents between 2000 and 2005 within the study area that have been reported to the Environment Agency. In addition, they also show the location of a groundwater flooding incident recorded by the Council. Table 8-4 provides details for the reported incidents, including the local geology and the date of the reported incident.

Table 8-4 Selected Flooding Records

Geological Unit*	Grid Reference	N°**	Reported Incident	Date
London Clay Formation	TQ 2375 6470	43	Waterlogged Garden	15/02/2001
	TQ 26 65	49	Blockage of w.t.	28/02/2001
	TQ 2377 6495	50	Occasional flooding in garden	21/03/2001
	TQ 23928 66217	57	Swampy garden, Near Pyl Brook, 2 streets away.	09/05/2001
	TQ 23528 65396	60	Water to top of skirting boards(?), Water coming through walls in October	17/05/2001
	TQ 24534 66645	68	Damp basement(his neighbour's also), Drainage problems?/unknown culvert	24/09/2001
	TQ 24832 66346	84	Underground stream causing rising damp? LC so likely to be surface drainage problem rather than water table. Suggested French drain, etc.	22/10/2002
	TQ 23598 66325	98	Water under floorboards, No water table. Ground may be saturated due to heavy rain. House slightly lower than neighbours. May be one off. New owner, no knowledge if this happened in 2000/01	22/01/2003

Geological Unit*	Grid Reference	N°**	Reported Incident	Date
	TQ 22490 65683	104	Damp Kitchen, Found well in garden 12 ft deep, with only 12" water in it. Hence not gw. Could be underground stream. Very close to Beverely Brook Culvert 14m away to west.	10/06/2003
Outcrop of Thanet Sand Formation	TQ 27096 64569	44	Water In Cellar Suspected Blockage, spring evident due to High Ck w.t., but blockage making gw build up	16/02/2001
	TQ 27125 64564	45	Water in Cellar, Suspected Blockage, spring evident due to High Ck w.t., but blockage making gw build up	16/02/2001
	TQ 2712 6456	47	Gw Blockage, spring evident due to High Ck w.t., but blockage making gw build up	19/02/2001
	TQ 2712 6456	48	Gw Blockage (1.5m BGL , few inches in cellar)	19/02/2001
Chalk	TQ 260 640	33	Water seeping into basement of shopping centre - Southside	02/01/2001

Note: * Geology of incident based on plotted location (Figures 1 & 5) & Environment Agency record

** Reference number as shown on Figures 8-1 and 8-5.

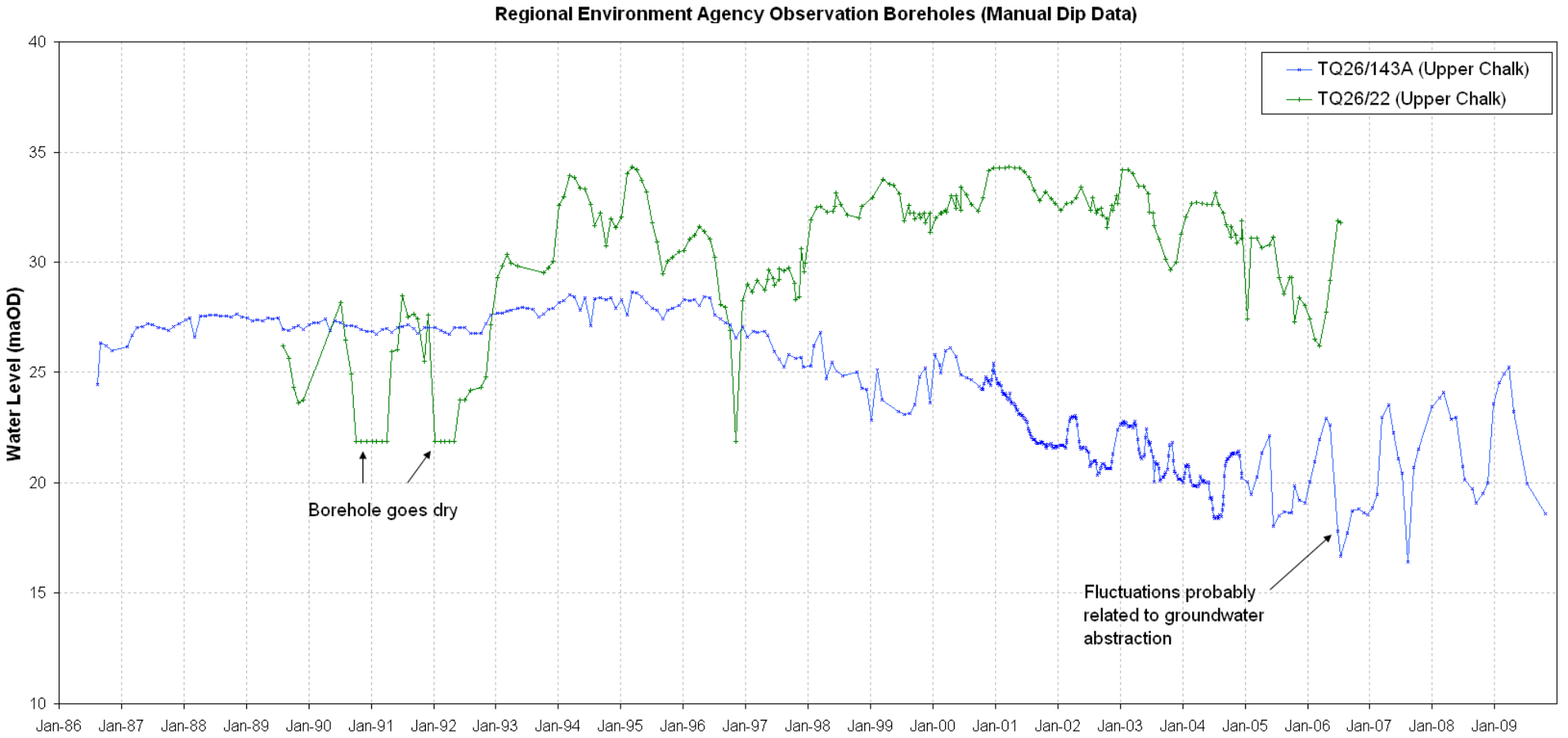
8.6.2 Table 8-4 demonstrates that the majority of reported incidents occurred during early 2001; a particularly wet year that resulted in both surface and groundwater flooding incidents in a number of locations across the country. Many of the incidents were located over the London Clay, which is an aquiclude and does not permit groundwater flow. Based on the available information to date, these incidents are probably related to poor drainage over clayey soils following heavy rainfall i.e. they are not groundwater flooding incidents.

8.6.3 The incidents reported to be on the Chalk or Thanet Sand Formation outcrop (i.e. south of the London Clay outcrop), are likely to be 'real' groundwater flooding incidents. This includes the property reported to the Council. The incidents are related to flooding of basements rather than groundwater springs arising at ground level.

8.7 Potential Groundwater Flood Risk Areas

8.7.1 Based on the (i) depth to the Chalk groundwater table in January 2001, (ii) the BGS records for the River Terrace Deposits, and (iii) the outcrop geology, potential groundwater flood risk areas have been identified (Figure C12). This is a preliminary assessment and could be refined using more local data and an improved understanding of the water balance for the area (groundwater abstraction and rainfall recharge etc).

Figure 8-1 Example Chalk Groundwater Hydrograph



9 Conclusions

9.1 Overview of Pluvial Flooding in Sutton

9.1.1 The results of the intermediate level 2D pluvial modelling combined with site visits and review of historical flood records at the Council, Thames Water and the Environment Agency indicate that pluvial flooding in the London Borough of Sutton is widely dispersed and scattered across the entire borough.

9.1.2 There are two key features associated with surface water flooding in the borough, as follows:

- The outputs from our intermediate level 2D pluvial modelling revealed eight (8) discrete surface water flooding locations along the up-stream side of the raised network rail embankment (running roughly west to east through the centre of the borough); and
- At least six (6) of the higher risk areas are narrow corridors associated with topographic valleys (likely once occupied by rivers) running roughly from south to north.

9.1.3 The surface water flooding in Hackbridge and Carshalton Beeches is more complex and highly linked with groundwater flooding. Both of these areas are identified at being of higher risk of groundwater flooding with the depth to the water table less than 2 metres below ground.

9.1.4 In terms of surface area Hackbridge is the single largest pluvial flood risk area within Sutton.

9.1.5 The risk of flooding from failure or surcharging of infrastructure has been assessed to a lesser extent due to limited data at the time of writing. Flooding hot spots where the capacity of the existing drainage system may be an issue have been highlighted based on local knowledge. Thames Water hold information on the capacity of the drainage system and carry out a rolling programme of asset maintenance and upgrade to address problems including upgrading works undertaken in the Wallington Station area of Sutton.

9.2 Risk to Existing Properties & Infrastructure

9.2.1 Depth maps generated from 2D intermediate pluvial modelling are included in Appendix D. These figures comprise insets over specific areas at risk from pluvial flooding. In order to provide a quantitative indication of potential risks, address point data, supplied by the Environment Agency, has been overlaid onto intermediate pluvial modelling results to establish the number of properties at risk within each specific area.

9.2.2 Table 9-1 below presents the approximate number of properties which may be affected in each of these areas during a 1 in 100 year rainfall event including a 20% allowance for climate change. Note that these are likely to be conservative figures as the modelling to date has not included for drainage via the existing networks.

Table 9-1 Summary of properties affected by pluvial flooding (1 in 100 yr event + Climate Change) within identified Critical Drainage Areas (CDAs)

No.	Area	Number of properties affected by surface water flooding > 500mm	Number of properties affected by any surface water flooding
1	Demesne Road, Wallington	**123** *of which 40 are flats*	**166** *of which 41 are flats*
2	Beddington, Wallington	**72** *of which 3 are flats*	**92** *of which 4 are flats*
3	Central Carshalton	**47** *including Heritage and Ecology Centre*	**125** *of which there are 3 flats, Conference Centre and Carshalton Baptist Church*
4	Mill Lane, Carshalton	**73**	**81** *including St Marys RC Junior and St Philomena's School*
5	Oldfields Road Area, Sutton Town South	**67** *including Tesco Superstore*	**92**
6	Stayton Road and Railway Line, Sutton Town South	**68**	**100**
7	Palmerston, Sutton Town North	**34** *of which at least 8 are businesses*	**114** *of which at least 9 have been identified as businesses*
8	Sutton Junction, Sutton Town North	**51**	**62**
9	Green Lane, Worcester Park (school)	**10**	**19** *of which 7 are flats*
10	Sports Ground, Worcester Park	**12**	**102**
11	Wandle Park Trading Estate, Hackbridge North	**39**	**83** *of which at least 12 are businesses*
12	Wandle Bridge, Hackbridge	**225** *of which at least 1 is a business*	**285** *of which at least 1 is a business*
	TOTAL	**821**	**1321**

9.2.3 The figures in Table 9-1 demonstrate that pluvial flooding in LB Sutton resulting from a 1 in 100 year rainfall event including climate change is likely to have the greatest impact, in terms of number of properties affected, in the Hackbridge area. Approximately 225 properties are modelled to have been affected by surface water of depths greater than 500mm.

9.2.4 Research into the local hydrogeology of the borough has also identified the presence of a high groundwater table. This poses greatest risk in the North-eastern section of the borough as illustrated in Figure C12. Groundwater levels of <2m bgl can be expected in this area due to a number of reasons including the hydraulic continuity between groundwater levels and the River Wandle, the presence of perched groundwater tables and the presence of 'made ground'.

9.3 Risk to Future Development

9.3.1 The Core Planning Strategy identifies that the Council will make provision for the borough's share of London's housing needs and for local needs in excess of 3,450 net additional dwellings by 2001-16. The manner in which these new dwellings will be located throughout the borough is shown in Table 9-2.

Table 9-2 Housing Provision (LB Sutton Core Strategy Dec 2009)

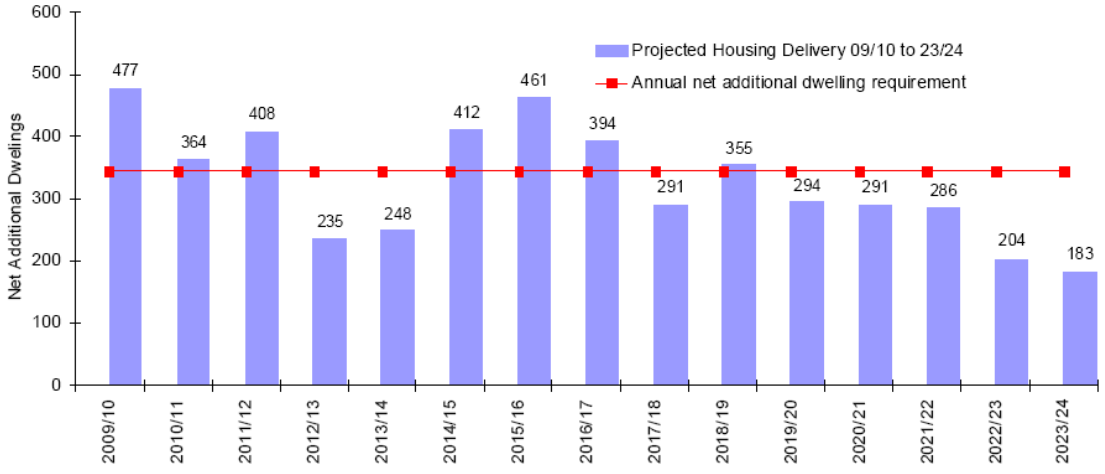
Area	Net additional dwellings (units)
Sutton Town Centre	2,000 – 2,150 (40%)
Hackbridge	1,000 – 1,100 (20%)
Wallington	500 – 550 (10%)
Other District Centres	500 – 550 (10%)
Remainder of the Borough	1000 – 1,100 (20%)

9.3.2 In addition, Table 9-3 and Figure 9-1 provide an indication of the housing trajectory for the borough over the longer term.

Table 9-3 Minimum Housing Requirements until 2024 (LB Sutton Core Strategy Dec 2009)

Delivery Period of Plan	PPS3 Requirements based on London Plan Targets
2009-10 to 2013-14	1,725
2014-15 to 2018-19	1,725
2019-20 to 2023-24	1,725
Total over 15 years	5,175

Figure 9-1 Housing trajectory (LB Sutton Core Strategy – Adopted December 2009)



9.3.3 Land available for development is scarce within the borough and is being put under increasing pressure due to the demand for new housing. It is essential that decisions are made through the spatial planning process which guarantee that land is used efficiently. However, it is also essential that the impact of future development on existing infrastructure, including the drainage systems, is assessed and adequately managed.

9.3.4 Findings from the Phase II SWMP identify that Hackbridge is at significant risk of flooding from pluvial and groundwater sources in addition to the risk posed by the River Wandle. Given the number of additional residential dwellings proposed for this area, it is important that the risk of surface water flooding is clearly understood in order that measures to mitigate this risk can be adopted.

9.4 Communicate Risk

Professional Stakeholders

9.4.1 There are various professional stakeholders which are in interested in increasing their knowledge of risks from surface water flooding. It is essential that the SWMP partnership actively engages with these groups, where appropriate, to share the findings of this report. This will ensure that emerging plans and policies are informed by the latest an improved understanding of surface water flood risk issues.

9.4.2 It is recommended that LB Sutton make the intermediate pluvial modelling mapped outputs available on their website for professional stakeholders and members of the public to access and view.

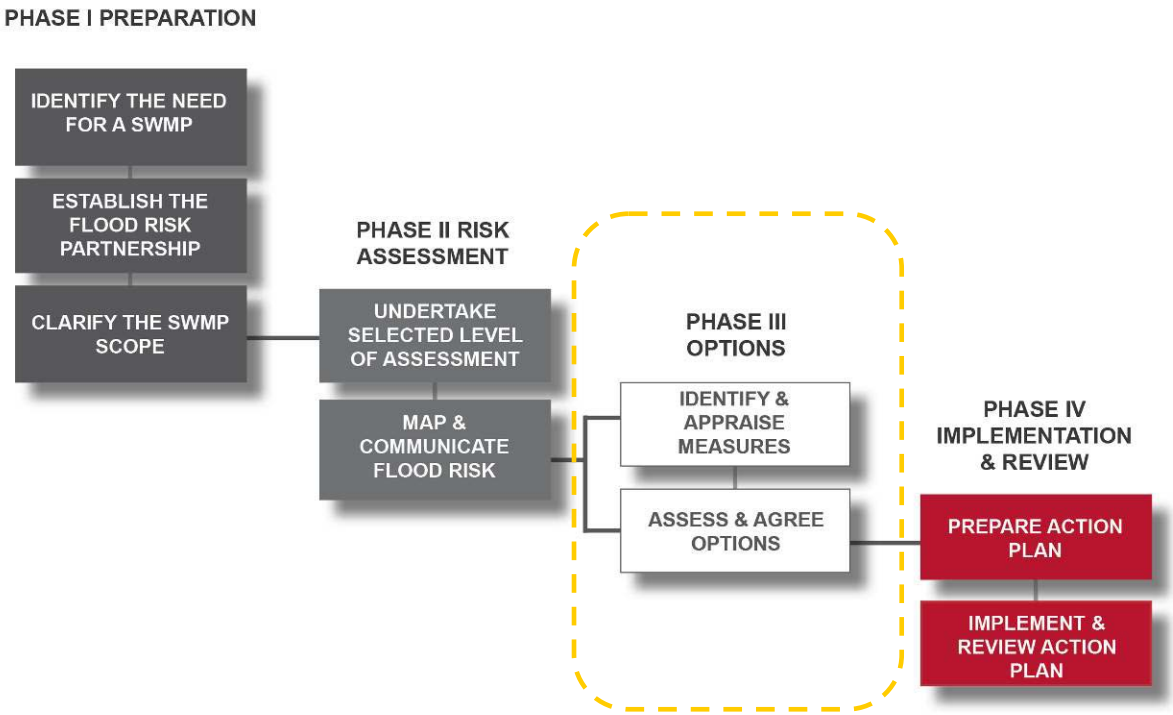
Local Resilience Forums

9.4.3 In line with the SWMP Technical Guidance it is strongly recommended that the information provided in the Phase II SWMP is issued to the Local Resilience Forum. Surface water flood maps and knowledge of historic flood events should be used to update Incident Management Plans and Community Risk Registers for the area. In addition, maps showing the depth of pluvial flooding during a range of return period rainfall events can be used to inform operations undertaken by emergency response teams especially near public buildings and major routes through the borough.

9.4.4 It is understood that LB Sutton are awaiting the completion of the SWMP prior to the preparation of the Multi-Agency Flood Plan (MAFP) for the borough. It is recommended that the results of the intermediate pluvial modelling are used to identify likely flow-paths and locations of ponding of surface water. This information can be used in parallel with Extreme Rainfall Alert (ERA) service provided by the Flood Forecasting Centre[15].

[15] The Flood Forecasting Centre was set up in 2008 by the Met Office and the Environment Agency to provide services to emergency and professional partners.

PHASE III: OPTIONS



10 Phase III Options

10.1 Introduction

10.1.1 Although this report and commission are solely for Phase I & II SWMP, we have included an indicative element of options identification as added value.

10.1.2 The purpose of Phase III is to identify a range of structural and non-structural options for alleviating flood risk in LB Sutton. These options should then go through a short-listing process to eliminate those that are not feasible or cost beneficial. The remaining options should then be developed and tested using a consideration of their relative effectiveness, benefits and costs.

10.1.3 It is reiterated that a Phase III is beyond the scope of this commission.

10.2 Quick Wins and Long Term Measures

10.2.1 The recommendations generated from this Phase I & II SWMP can be divided into 'quick wins' and longer term measures that will need to be further appraised and assessed should the LB of Sutton decide to undertake Phase III (Options Identification & Appraisal). Potential quick wins and long term mitigation measures are outlined below.

Surface Runoff - Quick Wins

10.2.2 Surface water runoff is the responsibility of landowners and the local authority.

10.2.3 LB Sutton are in the advantageous position of having a dedicated highway drainage team including drainage engineers who operate a rolling programme of repairs and improvements to the local highway drainage system. To this end, a large number of quick win solutions to local surface water flooding have already been implemented such as installing new gullies, soakaways, building bunds and installing drainage overflows.

10.2.4 A full list of highway drainage improvement works completed following the July 2007 flood event are included in Table 5-1 and illustrated in Figure C-03. While a large number of improvement works have been completed, it is important that the following measures are also undertaken:

- Build upon Figure C-03 to create a GIS database containing the ranking of each road in relation to the priority of gully clearance.
- Maintain gully clearing routine and highlight to local residents when this has been done via a letter drop/comment slip so that any problems can be highlighted.
- The road under Wallington Bridge should not be accessed at times of heavy rain. Warning lights should be installed to inform drivers on when it is unsafe.
- Put in place a road closure/diversion procedure for times of flood.
- Raise awareness:
    - Perform a letter drop to highlight the improvement works that have been undertaken as well as works that are planned for the future, highlighting maintenance regimes. This should have a comments section to gather data on any outstanding issues.

- Hold a public meeting following the letter drop where residents can highlight any issues. This could include a talk from the key partner organisations – Environment Agency, Thames Water and LB Sutton – on the work that is being undertaken and who is responsible. Such a meeting should also outline how residents can help themselves and highlight their responsibility for maintaining private drainage, soakaways, driveway drainage etc.

- Follow the public meeting with a newsletter/letter drop summarising the key points.

Surface Runoff - Long Term Measures

10.2.5 In addition to the potential quick wins, a number of options for longer term measures are outlined below.

- Continue to maintain the existing highway drainage infrastructure;
- Work with partners to progress highway drainage improvements;
- Work with the Thames Water and the Environment Agency with reference to drainage design at Hackbridge;
- Liaise with the Environment Agency with regard to the use of deeper soakaways in Hackbridge;
- LB Sutton to develop a Multi-Agency Flood Plan (MAFP);
- Review emergency plans and test group cascades.

Sewer Flooding - Quick Wins

10.2.6 Thames Water is responsible for the provision and maintenance of the main trunk sewers to which the local highway drainage connects.

10.2.7 Current accepted practice for the design of new sewerage systems is to design sewers for a 1 in 30 year rainfall return period as set out in Sewers for Adoption 6. Common industry practice for minimum design standards for sewer flooding schemes can be summarised as:

- Internal property 30 years
- External property 20 years
- Other areas 10 years

10.2.8 Consumers may desire a higher standard of protection from sewer flooding, however there is currently no statutory requirement on the water utility to provide this.

10.2.9 The following measures have been identified as quick wins which Thames Water could investigate, where appropriate, in order to mitigate, to varying degrees, the risk of sewer flooding in LB Sutton.

- Where appropriate, create a maintenance regime for jetting out of soakaways and make this available to local partners.
- Attend regular Flood Group meetings with LB Sutton partners.

- Assess the capacity and current operation of the surface water drainage system crossing the railway line at Beddington Gardens (CCTV survey) to reduce the risk of flooding in the future which has been identified in the pluvial modelling completed for this study.
- Investigate potential and if possible remove 90° bend in surface water sewer at Cedar Road (Sutton Town Centre).
- Where appropriate, consider the installation of extra soakaways at Revell Road / Cecil Road in conjunction with the Highway Authority.
- Assess potential improvements at Wallington Road Bridge.
- Attend public meeting with LB Sutton partners to promote local schemes and improvement works.
- Work in partnership with LB Sutton and the Greater London Authority during Phase III SWMP and the Drain London Project through provision of InfoWorks CS sewer network model or undertaking model runs to assist with these studies.

Sewer Flooding - Long Term Measures

10.2.10 In addition to the quick wins outlined above, there are a number of longer term mitigation measures which Thames Water in collaboration with Sutton (if required) could consider.

- It is recommended that reference is made to the Thames Water drainage network plans and 'red, amber, green' capacity plans, where these are available, which highlight areas within the network where the capacity of the system may contribute to the risk of flooding. This will highlight where larger capital projects may be required such as increasing the size of the local sewer network or providing attenuation storage.
- In areas which are prone to surface water ponding resulting from insufficient capacity (as opposed to issues with gully connections, which are the responsibility of LB Sutton), it is recommended that Thames Water investigate the potential for increasing the capacity of the sewer network in these locations. Any work should be clearly documented and provided to LB Sutton for their records and information.
- It is also recommended that an assessment is undertaken of the drainage infrastructure out falling into the Beverley Brook. It should be determined whether there is sufficient capacity within the system and if not, whether there is potential to provide some on-line attenuation prior to outfall into the watercourse during times of flood.

Small Open Channels and Culverted Watercourses - Quick Wins

10.2.11 LB Sutton is responsible for minimising the risk of flooding from 'ordinary watercourses' which are not the responsibility of the Environment Agency (i.e. non main-river).

10.2.12 The following measures have been identified as potential quick wins which LB Sutton should investigate with regard to open channels and culverted watercourses:

- Highway drainage team to liaise with parks team to create a GIS layer highlighting the location of small channels and culverted watercourses which are the responsibility of LB Sutton.
- Following identification of watercourses, complete a site visit to document the condition of the channels and the location and condition of associated infrastructure.

- Create/document and implement a maintenance regime along these channels and watercourses.

Small Open Channels and Culverted Watercourses - Long Term Measures

- It is recommended that further work is undertaken to map out the local authority's ordinary watercourses as well as details regarding assets along their course, such as their condition and maintenance regime.

- In order to achieve this, it is suggested that the Detailed River Network is obtained from the Environment Agency and used as a starting point. Through site visits and reference to LiDAR topographic data as well as the plans of Thames Water assets where necessary, it should be possible to identify the pathways of any ordinary watercourses.

- Continue maintenance of small open channel watercourses and culverted sections.

Groundwater Flooding - Quick Wins

10.2.13 There is evidence to suggest that groundwater flooding occurs in LB Sutton. Therefore, it is important that the distribution of groundwater flood risk is assessed at a local scale. The results will support decision making with respect to future land development, future co-ordinated investments to reduce the risk and informing the assessment of suitability for infiltration SUDS.

10.2.14 The following additional activities are recommended to inform Phase III of the Surface Water Management Plan:

River Terrace Gravels

- Collation of historic site investigation reports for developments over the River Terrace Gravels to obtain an improved groundwater level information (to improve the understanding of flood risk); and

- Structural contouring of the River Terrace Gravels to understand the thickness of these deposits across the Council area (to improve the understanding of flood risk).

The Chalk and Basal Sands

- Processing of water company abstraction data to understand the balance of rainfall recharge and abstraction in the area. This can be used to understand the potential flood risk from rising Chalk groundwater levels if certain water company abstractions ceased (temporarily or permanently); and

- Identify planned future trends in groundwater abstraction through liaison with the water company.

General

- Acquisition of 1:10,000 scale geological mapping, if it exists, for the areas identified as being at potential risk from groundwater flooding;

- Assessment of groundwater / surface water interactions and the influence of anthropogenic activities so that the integrated mitigation of flood risk proposed at Stage 3 of the SWMP is better informed;

- Gain an improved understanding of the areas where cellars / basements exist (within the areas identified as being at potential risk from groundwater flooding; and
- Identification of data gaps and further recommendations e.g. infiltration testing, window sampling to determine the nature of Drift deposits, installation of groundwater dip-wells for a flood risk warning system.

10.3 Targeted Approach to Critical Drainage Areas

10.3.1 The intermediate level risk assessment has provided further information with respect to the following five Critical Drainage Areas within LB Sutton:

- Hackbridge
- Sutton Town Centre
- Worcester Park
- Carshalton
- Wallington

10.3.2 The Defra SWMP Technical Guidance recommends that a detailed assessment is undertaken in areas that are identified as 'hotspots' for surface water flooding following the intermediate assessment. It will not always be appropriate to undertake detailed integrated urban modelling (see Figure 5-2 Levels of Intermediate Pluvial Modelling) for every CDA and the following text provides a summary of where more detailed assessment through modelling is recommended in LB Sutton.

Hackbridge

10.3.3 Due to the complex nature of flood risk in Hackbridge and the proposals for future development as a sustainable suburb, it is important that further assessment is completed in this area in order to clearly understand the causes, probability and consequences of flooding, and to provide realistic risk based solutions. Any future assessment in this area will need to include detailed information from Thames Water regarding the capacity of the local drainage network; information from the Environment Agency with respect to the River Wandle and its flood defences and detailed groundwater information. This information should be used to steer future drainage design for new development, and to inform strategic investments to the existing drainage system. Coupled with this approach, it is also crucial that developers undertake studies to demonstrate how their development will be sustainable with respect to surface water management and drainage provision.

Sutton Town Centre

10.3.4 Flood risk in Sutton Town Centre is primarily caused by pluvial flooding. LB Sutton has only one record of sewer flooding at this location. Intermediate level direct rainfall pluvial modelling completed as part of this study has highlighted where pluvial flooding is a potential risk. It is not considered that further detailed modelling would provide any material benefit at this time. However, it is important that further information is obtained from Thames Water with regard to network capacity in order to ensure that future development can be accommodated.

10.3.5 It is strongly recommended that future developers undertake adequate consideration of drainage and the sustainable management of surface water on their site. Full details should be required as part of their planning application submission to LB Sutton for approval.

Worcester Park

10.3.6 Flooding in Worcester Park is caused by fluvial flooding from the Beverley Brook as well as pluvial flooding as surface water from the surrounding area is directed towards the channel of the Beverly Brook. The Environment Agency has undertaken hydraulic modelling of the Beverley Brook and is working towards identifying a viable option to manage the flood risk in and around Worcester Park. The scheme is currently undergoing an options appraisal in order to ensure that any scheme proposed for Worcester Park represents the best use of public money whilst also reducing the flood risk to homes and businesses. In the meantime channel constrictions including a redundant footbridge, bank vegetation and fences have been removed to reduce the risk of blockage during peak flows.

10.3.7 In addition to hydraulic modelling of the Beverley Brook undertaken by the Environment Agency, intermediate level direct rainfall pluvial modelling has been completed for Worcester Park as part of this study.

10.3.8 A second potential option to mitigate flood risk in this area may be to utilise space in Cuddington Park at the headwaters of the Beverley Brook. As outlined in this study, surface water flooding is highly linked with flooding from rivers and this is particularly true in Worcester Park. As a result of these interactions, potential solutions that reduce peak discharges in the Beverley Brook will also reduce the risk of surface water flood risk in high risk areas such as Green Lane.

10.3.9 Although only at concept phase, the opportunity to utilise this Council-owned park which is ideally geographically situated for attenuation of storm water appears, anecdotally, to be worthy of further investigation as part of a future Phase III SWMP.

Carshalton

10.3.10 Flooding in Carshalton is caused by a combination of factors including a high groundwater table, the Carshalton Branch of the River Wandle, and pluvial flooding. It is important that reference is made to Thames Water capacity plans to highlight any potential pinch points in the system where mitigation measures may be required. It is not considered that further pluvial modelling is required at this stage.

Wallington

10.3.11 Intermediate level pluvial modelling completed as part of this study has highlighted that flood risk in Wallington is primarily caused by surface water flooding pooling at low points in the highway.

10.3.12 It is suggested that further work is undertaken in this area through liaison with Thames Water. This should include reference to the Thames Water drainage capacity plans, a drainage review and CCTV survey of the surface water sewer in Beddington Gardens and a review of drainage at Wallington Station and Demesne Road.

10.3.13 A more detailed study could be used to model the interaction between the Thames Water network and pluvial flooding. However, it is not considered that the outcomes of this modelling would influence mitigation measures proposed.

10.4 Potential Options

10.4.1 Table 11-1 below illustrates the critical drainage areas, sources of flooding and potential development pressures which should be used as a guide to where further work may be required.

Table 10-1 Summary of Critical Drainage Areas and Way Forward

Critical Drainage Area	Sources of Flooding	Development Pressures (additional dwellings)	Way Forward
Hackbridge	Pluvial Groundwater	1,000 – 1,100 (20%)	Further assessment required of groundwater/surface water interactions
Sutton Town Centre	Pluvial	2,000 – 2,150 (40%)	No further pluvial modelling at this time, interrogate TW records for further information on sewer network capacity
Worcester Park	Pluvial	500-550 (10%)	No further pluvial modelling at this time, work with EA with regard to Beverley Brook levels which will improve surface water drainage in the area.
Carshalton	Pluvial Groundwater	500-550 (10%)	No further pluvial modelling at this time, interrogate TW records for further information on sewer network capacity
Wallington	Pluvial	500-550 (10%)	No further pluvial modelling at this time, interrogate TW records for further information on sewer network capacity

10.5 Coordinated Future Studies

10.5.1 There is a need for improved co-ordination of flood risk and water-related studies both within and across the London Borough of Sutton. There are currently four (4) studies underway or planned for the near future which may affect flood risk and water use in Sutton. These are outlined below:

(1) Flood Risk Management Strategy Beverley Brook (EA)

10.5.2 It is understood that the Environment Agency has been considering a Flood Risk Management Strategy for the Beverley Brook and River Wandle. It is suggested that any flood risk management strategy for the Beverley Brook and River Wandle that is developed in the future is co-ordinated and closely linked with the next SWMP Phases (Phase III - Options and Phase IV – Implementation).

(2) Sutton and East Surrey Water NEP Study

10.5.3 Part of Sutton & East Surrey Water's investment under AMP 5 covers a programme of studies under the National Environment Programme (NEP). These studies include research into the potential impact of abstraction for the Chalk aquifer and River Wandle. This study is due for completion in March 2015.

10.5.4 Since there is inter-dependency of abstraction, groundwater levels, river flows and surface water flood risk in the eastern portion of the Borough including Hackbridge, it appears that there is an opportunity to co-ordinate or link these studies within Phase 3 of the SWMP.

(3) Hackbridge Masterplan

10.5.5 The London Borough of Sutton is currently in the process of creating a Master Plan for Hackbridge. Based upon the outputs from our 2D intermediate pluvial modelling combined with historical pluvial flood records, we recommend the Council undertake an Integrated Drainage Strategy to inform the Hackbridge SPD (in line with Core Planning Strategy policy BP7) and before any allocations are made in the proposed Site Development Policies DPD.

10.5.6 The Phase I and II SWMP has shown that Hackbridge is in an area which is heavily affected by flood risk from multiple sources which may constrain future development being:

- Fluvial flooding – Flood Zones associated with the River Wandle will define development type and location in accordance with PPS25 guidelines.
- Groundwater flooding – Water tables in this area are known to be at or just below the ground surface. This will impact on the physical construction of buildings in the area and will constrain development options.
- Pluvial flooding – intermediate 2D pluvial modelling has highlighted areas of Hackbridge as potentially being at increased risk of significant pluvial flooding.
- Surface Water drainage – This is a concern as local topography limits the potential for discharge to local watercourses. The capacity of the local drainage system will limit the potential for discharge to local surface sewers. Prior to use of deep soakaways, go-ahead is required from the EA.

10.5.7 We recommend that in order for the Hackbridge Masterplan to progress, all of the above issues need to be considered in more detail. This Phase III study will need to be informed by the preliminary results of the Sutton and East Surrey NEP Study and will require further details from Thames Water on the capacity of the local drainage system in Hackbridge.

(4) Links with Drain London (Tier 2 and 3)

10.5.8 Through this study, we have established a solid baseline from which the Council in coordination with the Greater London Authority can prioritise future studies and investments (e.g., integrated urban drainage modelling, capital investments, linked asset register, etc.) as part of Tiers 2 and 3 of the Drain London study.

10.5.9 As a result of the completed Phase I & II SWMP, the London Borough of Sutton is in an advanced position relative to the other 33 London Boroughs to road test implementation options on behalf of the Drain London Forum.

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Appendices

Appendix A: SWMP & Flood Group Contact List

Appendix B: Project Governance Framework

Appendix C: General Figures

Appendix D: Intermediate Pluvial Modelling Figures

Appendix E: Intermediate Pluvial Modelling Methodology

Appendix A: SWMP & Flood Group Contact List

London Borough of Sutton Flood Group: Membership List, 24 February 2010

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Appendix B: Project Governance Framework

London Borough of Sutton SWMP
Project Governance Framework

Final Framework
July 2010




Prepared for

Table of Contents

1 LB Sutton Surface Water Flood Risk Management Governance Framework

1.1 Sutton Flood Group - Terms of Reference

Background

Following the 20th July 2007 flood event, approximately 1200 properties were affected in the London Borough of Sutton by a combination of different flood sources, however most were identified as being affected by surface water flooding. According to Defra there are approximately 9,900 properties at risk from surface water flooding within Sutton.

The Sutton Flood Group was set up by the Council following the July 2007 flood event. It includes representatives from the Environment Agency, Thames Water and the Council (LB of Sutton, multi-departmental representation; environmental sustainability, strategic planning, emergency planning, parks and highways drainage).

The aim to address all sources of flood risk in a comprehensive way is further supported by the draft Floods and Water Management Bill which requires unitary authorities to undertake a leadership role with regard to local flood risk management. Other important considerations and ongoing areas of work being progressed by the Council which set the context for addressing flood risk issues within the Borough include:

(i) London Borough of Sutton Emergency Plan

(ii) London Borough of Sutton One Planet Living Action Plan (November 2009)

(iii) Relevant action points under NI189 on Flood Risk Management (see EA programme) and NI188 on Climate Change Adaptation

(iv) Sutton's Local Development Framework (LDF) – ongoing preparation of planning policies on flood risk/ climate change adaptation for inclusion in the emerging Site Development Policies DPD, the Sutton Town Centre Plan, the Hackbridge SPD and the proposed revision to the 'Sustainable Design and Construction' SPD within the context of national Planning Policy Statements (PPS), London Plan policies, current best practice and data on all sources of flood risk based on the Strategic Flood Risk Assessment (SFRA) and SWMP. The SFRA Level 1 and Level 2 Reports prepared by Scott Wilson on behalf of Sutton, Croydon, Merton and Wandsworth in December 2008 and July 2009 in line with PPS25 will shortly be updated in the light of the SWMP study and the EA's updated '2-D' modelling data for the River Wandle expected in late spring/ early summer 2010

(v) The development of a 'Borough Climate Change Adaptation Strategy', a 'Climate Change Adaptation Action Plan' for Hackbridge to inform the SPD and a GIS-based 'Climate Change Risks and Vulnerabilities Assessment Tool' by 2011 as part of Sutton's participation in the EU GRaBS project (Green and Blue Space Adaptation for Urban Areas and Eco-Towns). As part of GRaBS, principles established through the 'LiFE' project (Long-Term Initiatives for Flood Risk Environments) are now being developed further by BACA Architects in preparing a 'Toolkit of Flood Risk Adaptation/ Management measures' for application in Hackbridge and elsewhere within the Borough.

Recent summer downpours (2008 & 2009) have been a reminder of the consequences of surface water flooding and the fragility of local infrastructure to heavy rain. This is compounded by new pressures on the existing drainage systems from new growth and a mixture of different asset owners, including the Environment Agency, the Council, Transport for London, and Thames Water.

Given the interactions between these issues, the drainage of urban areas is a complex issue requiring an integrated approach by a range of responsible organisations.

It is proposed to expand the Sutton Flood Group to include Transport for London (TfL) as approximately 5% of the drainage assets within Sutton are owned by TfL. Similarly, Sutton & East Surrey Water operate several groundwater extraction wells which has an affect on local groundwater levels.

The Council has now committed to the production of a Surface Water Management Plan (SWMP) and to investigate the interaction of flood risk sources, identify sustainable solutions and help produce a co-ordinated investment plan.

1.2 Objectives

To create a Flood Group and SWMP for the London Borough of Sutton, who through a partnership approach, will assess the mechanisms of flooding, identify appropriate options to mitigate flood risk and co-ordinate future drainage and flood risk investments.

Objectives:

- Integrate and share 'essential partners' knowledge concerning drainage and flood risk issues (main river, ordinary watercourses, groundwater, sewer and pluvial flood risk) in seeking to deliver NI1189 targets;
- Improve co-ordination between the 'essential partners' (Thames Water, LB of Sutton, and the Environment Agency);
- Provide a forum and means of resolving flood risk issues in a coordinated manner;
- Provide a forum to influence emerging LDF policies, proposals and guidance on flood risk/ climate change adaptation issues in order to ensure that all new developments avoid, manage and reduce all sources of potential flood risk to and from the development and are fully adapted to the impacts of climate change by incorporating SUDS, drainage mechanisms and other measures as appropriate;
- Provide a forum to review key 'GRaBS' project outputs (i.e. the Borough Climate Change Adaptation Strategy, the Climate Change Adaptation Action Plan for Hackbridge and the Climate Change Risks and Vulnerabilities Assessment Tool).

1.3 Links to Drain London

This section sets out how we propose to establish links with the Drain London Project to prevent overlap and promote synergies between these two studies. In the first instance, we propose that Tom Sampson (EA SWMP coordinator) is the link between the Sutton SWMP and Drain London. Matthew Graham (Scott Wilson PM) will ensure that the interface between Drain London and the Sutton SWMP is embedded into our service offering.

Background – Drain London

In 2007 the Drain London Forum was established to bring together representatives from organisations with the information and / or responsibility for managing surface water drainage in London. The Forum has developed into a committed and effective partnership, which has delivered a study into the data holdings of all its members and recommended strategies for sharing the data among them. The membership includes representation from Defra, Environment Agency, Government Office for London, Greater London Authority, London Boroughs, London Councils, London Development Agency, Thames Water and Transport for London.

The Drain London Forum has six aims:

1. To assess the quality and quantity of information on the location, ownership and capacity of surface water drainage in London
2. To assess the location, frequency, severity and cause of surface water flooding in London, and the impact of surface water flows on the tributary river network
3. To recommend appropriate data management measures (platforms, access, maintenance and compatibility with other systems – e.g. hydrological model)
4. To assess the capacity of the surface water drainage network and urban river networks to manage future increases in rainfall and the impact of new development and "urban creep".
5. To identify current and future flood hot spots and their causes
6. To identify and prioritise solutions and determine responsibility to deliver actions including areas where SUDS or strategic surface water flood management options may be needed.

1.4 Links to National Indicator 189

The London Borough of Sutton has been issued a target to deliver a Surface Water Management Plan (SWMP) as part of their local agreement under National Indicator (NI) 189. The NI 189 targets are periodically reviewed and progress is monitored by the Environment Agency. This draft partnership governance document along with the Phase 1 & 2 SWMP should help to solidify the working and operational arrangements between the Environment Agency and the Council.

Approach

The Sutton Flood Group will consist of representatives from the key 'essential partners' and local stakeholders (listed below), involved in local flood risk management and operation of drainage assets and water infrastructure in Sutton:

Membership

Essential Partners:

- LB of Sutton
- Environment Agency (EA)
- Thames Water (TW)

Local Stakeholders:

- Transport for London
- Greater London Authority (Drain London)
- Network Rail
- EDF Energy
- Natural England
- Sutton and East Surry Water

Each organisation listed as an 'essential partner' above will nominate a representative to attend future Sutton Flood Group meetings. The Council will take the lead role in coordinating the Flood Group.

The Sutton Flood Group will have two main functions; a) a strategic function to contribute to the delivery of the SWMP and work to establish a shared understanding of flood risk and agree a coordinated approach to reduce the risk and b) an operational function to improve the co-ordination of flood incident management and emergency response.

Area of Study

The Sutton Flood Group with cover the administrative boundary of the LB of Sutton, a map identifying the extent of the study area is appended.

Outputs/Benefits

- Greater understanding of urban drainage by a range of organisations;
- A shared understanding of flood risk across the Council, Thames Water and the Environment Agency;
- Efficiency savings for 'essential partners' though achieving outcomes;
- Appraisal of surface water drainage options;
- Greater certainty for developers concerning appropriate drainage;
- Quicker, more certain decisions on development and infrastructure provision; and
- Overall reduction in flood risk to LB Borough of Sutton (primarily driven through the latter SWMP stages 3 and 4 – dependent upon available funding).

2 Roles and Responsibilities and Communication

2.1 Key Roles and Responsibilities

The key roles and responsibilities of those involved in the project are set out in Table 1 below. The project team structure comprises a Strategic Management Group led by the LB of Sutton. The Council is the lead partner for the production of the SWMP and is responsible for ensuring that objectives are set and met and that a partnership approach is adopted.

The Environment Agency is responsible for sharing information about river flows, levels and flooding, river flow models, catchment flood management plans, reported flooding incidents, DEM data (e.g. LiDAR), interactions between rivers or the sea and drainage systems, operation and maintenance regimes and long term investment plans (Defra, SWMP Technical Guidance, 2009).

Thames Water is responsible for sharing information about the sewer network capacity and performance, reported flooding incidents, sewer network models, costs and practicalities of sewer rehabilitation, Drainage Area Plans and sewerage management plans, long term investment plans, and sustainable drainage systems in their control (Defra, SWMP Technical Guidance, 2009).

Table 1 Key roles and responsibilities

Tier 1 - Strategic Management Group			
Organisation	**Name**	**Title**	**Role**
LB of Sutton	Chris Reid	Head of Environmental Sustainability	Overall lead on local flood risk management activities within the Council.
LB of Sutton	Patrick Whitter	Principal Research Officer	Provide support and deputise for PM when necessary.
Thames Water	Mark Dickinson	Performance Manager, Asset Management	Share data on the performance of Thames Water assets within the administrative area of Sutton. For full SWMP, share sewer model so that an assessment of all sources of risk can be undertaken.
Environment Agency	Tom Sampson / Berhe Kesete (NI 189)	Technical Specialist	Overview role for Inland Flooding, provide guidance on methodology, share best practice and provide data.
Scott Wilson	Matthew Graham	Principal Consultant	Technical support and delivery of SWMP.

Table 2 Key roles – Operational Management Group

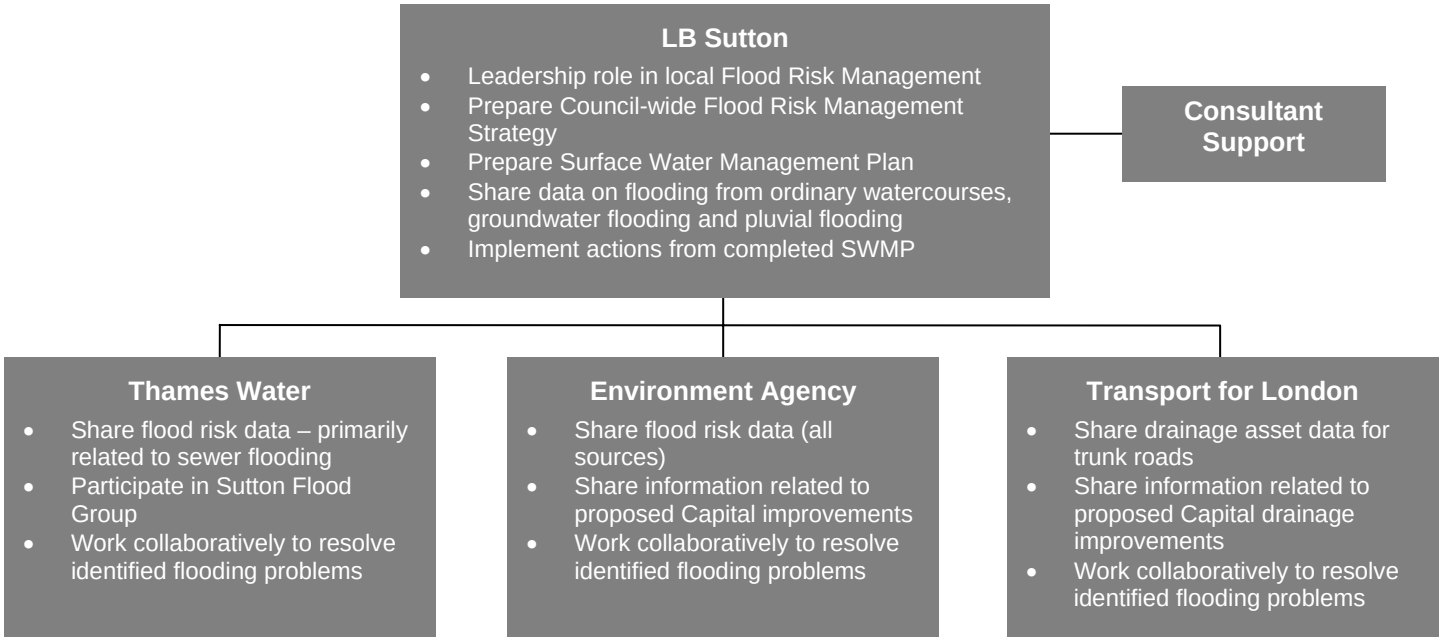
Tier 2 - Technical & Operational Management Group			
Organisation	**Name**	**Title**	**Role**
LB of Sutton	Gerry McLaughlin	Drainage Engineer	Operational support Operational maintenance
LB of Sutton	Ian Kershaw	Acting Emergency Planning Officer	Linking SWMP and SFRA with Multi-Agency Flood Plan / Severe Weather Plan
Thames Water	Mark Dickinson	Asset Management	Operational manager
Environment Agency	Sarah Bowbrick	Operations Delivery Technical Specialist	Operations and maintenance of EA main rivers - the Pyl Brook, Beverley Brook, and River Wandle

The aim of the Strategic Management Group is to make difficult decisions about flood risk management overall. This includes severe weather incident management, operational maintenance, future flood risk investments and planning. It will also serve as a 'local scrutiny committee' for the review of the SWMP.

The Strategic Management Group should meet every 2 - 3 months to discuss issues and matters brought forward by the Operational Management Group. The Operational Management Group is intended to serve as the 'day-to-day' flood risk group delivering the flood risk system operations and maintenance on the ground.

It is envisaged that there will be two-way communication between the Strategic Management Group and the Operational Management Group through the regularly scheduled meetings.

2.2 Proposed Project Governance Structure



2.3 Lines of Communication

The following lines of communication and procedures are proposed during the life of the project:

- Chris Reid, the overall Flood Risk Sector / Portfolio Manager within Sutton;
- Patrick Whitter, the LB of Sutton Project Manager will be the main point of contact for the SWMP;
- Matthew Graham, the Scott Wilson project manager, will be the main point of contact for Scott Wilson;
- All communications with Thames Water will be considered confidential (to ensure a smooth exchange and flow of data between 'essential partners');
- Any issues raised by the SWMP Strategic Management Group, including any queries or comments on the methodology will be filtered through Chris Reid;
- The Strategic Management Group will be represented by a single representative and will nominate a reserve deputy member within each organisation.

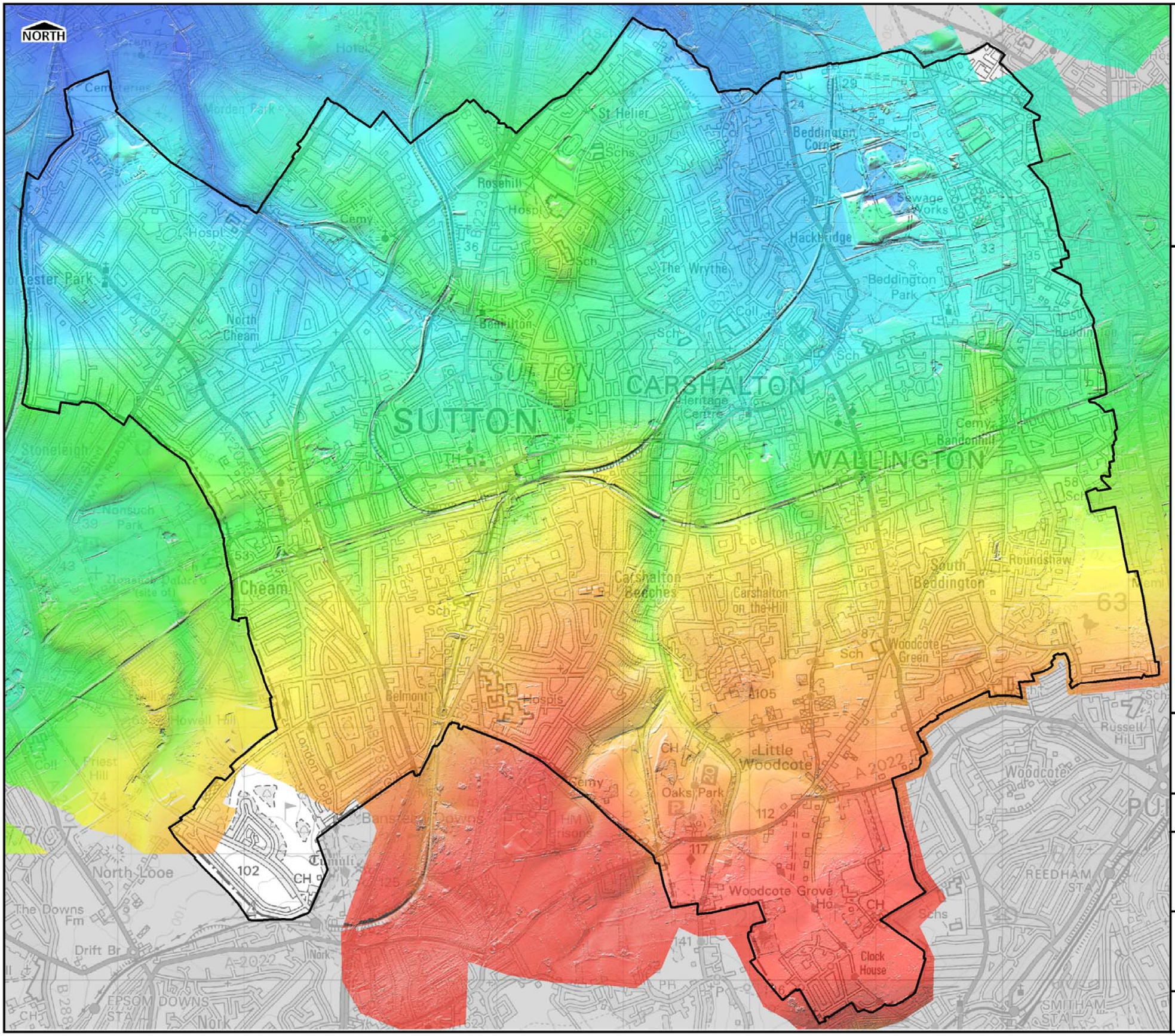
The inception meeting and overview workshop took place on 12 November 2009. A progress meeting has been set up for the 5th of February 2010 and a Sutton Flood Group meeting has been set up for the 24th of February.

The availability of key Thames Water and Transport for London data has been identified as the 'critical path' for this project. We have taken this into account by establishing a draft project governance document including terms of reference prioritising the data collection.

2.4 Agreed By

……	……	……
For LB of Sutton	**For** Environment Agency	**For** Thames Water
Name:	Name:	Name:
Date:	Date:	Date:

Appendix C: General Figures



London Borough of Sutton

Sutton

Surface Water Management Plan

Legend

LB Sutton Administrative Boundary

Elevation [mAOD]

10.0
30.0
50.0
70.0
100
130

Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

LiDAR Topographic Survey

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6-8 Greencoat Place
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Tel: (020) 7798 5000

Scott Wilson

FIGURE 01

London Borough of Sutton

Sutton

Surface Water Management Plan

Legend

- LB Sutton Administrative Boundary

Susceptibility to Surface Water Flooding

- More
- Intermediate
- Less

Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

Areas Susceptible to Surface Water Flooding

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Scott Wilson

FIGURE 02

London Borough of Sutton

Sutton

Surface Water Management Plan

Legend

- LB Sutton Administrative Boundary

Susceptibility to Surface Water Flooding

- More
- Intermediate
- Less
- Reported Flood Incidents, July 2007
- LB Sutton 'Floodplan Priority Areas'
- Drainage Improvement Works, post July 2007

Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

Recorded Flood Incidents & Drainage Improvement Works

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Tel: (020) 7798 5000

Scott Wilson

FIGURE 03

London Borough of Sutton

Sutton

Surface Water Management Plan

Legend

Sutton Borough Boundary

Sewer Height Diameter

900 to 5,500	(448)
400 to 900	(1612)
300 to 400	(1839)
200 to 300	(7054)
0 to 200	(2894)
0 to 0	(6099)

Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

Thames Water Sewer Network

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6-8 Greencoat Place
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Tel: (020) 7798 5000

Scott Wilson

FIGURE 04

London Borough of Sutton

Sutton

Surface Water Management Plan

NORTH

Wood Street, Sutton, CR4 4
Orchard Avenue, Sutton, CR4
Eindhoven Close, Carshalton, Sutton, SM5 2FD
Philips Close, Carshalton SN2 2FE
Nightingale Road, Carshalton
Nightingale Close, Sutton, SM5 2
Cheam Common Road, Sutton
Buxton Crescent, Cheam, Sutton, SM3
Church Hill Road, Cheam, Sutton
Manor Road North, Wallington, SM6
Cedar Road, Sutton, SM2
Sprucedale Gardens, Wallington
Woodmansterne Road, Carshalton

SUTTON
CARSHALTON
WALLINGTON

Legend

- LB Sutton Administrative Boundary

DG5 Register: Number of sewer flooding incidents recorded by Thames Water in the last 10 years

- 1 - 2
- 3 - 5
- > 5

- Sewer Flooding Records, July 2007

Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

Recorded Incidents of Sewer Flooding

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FIGURE 05

London Borough of Sutton

Sutton

Surface Water Management Plan

Legend

- LB Sutton Administrative Boundary
- Main Rivers
- Flooding from open channels & culverted watercourses, July 2007

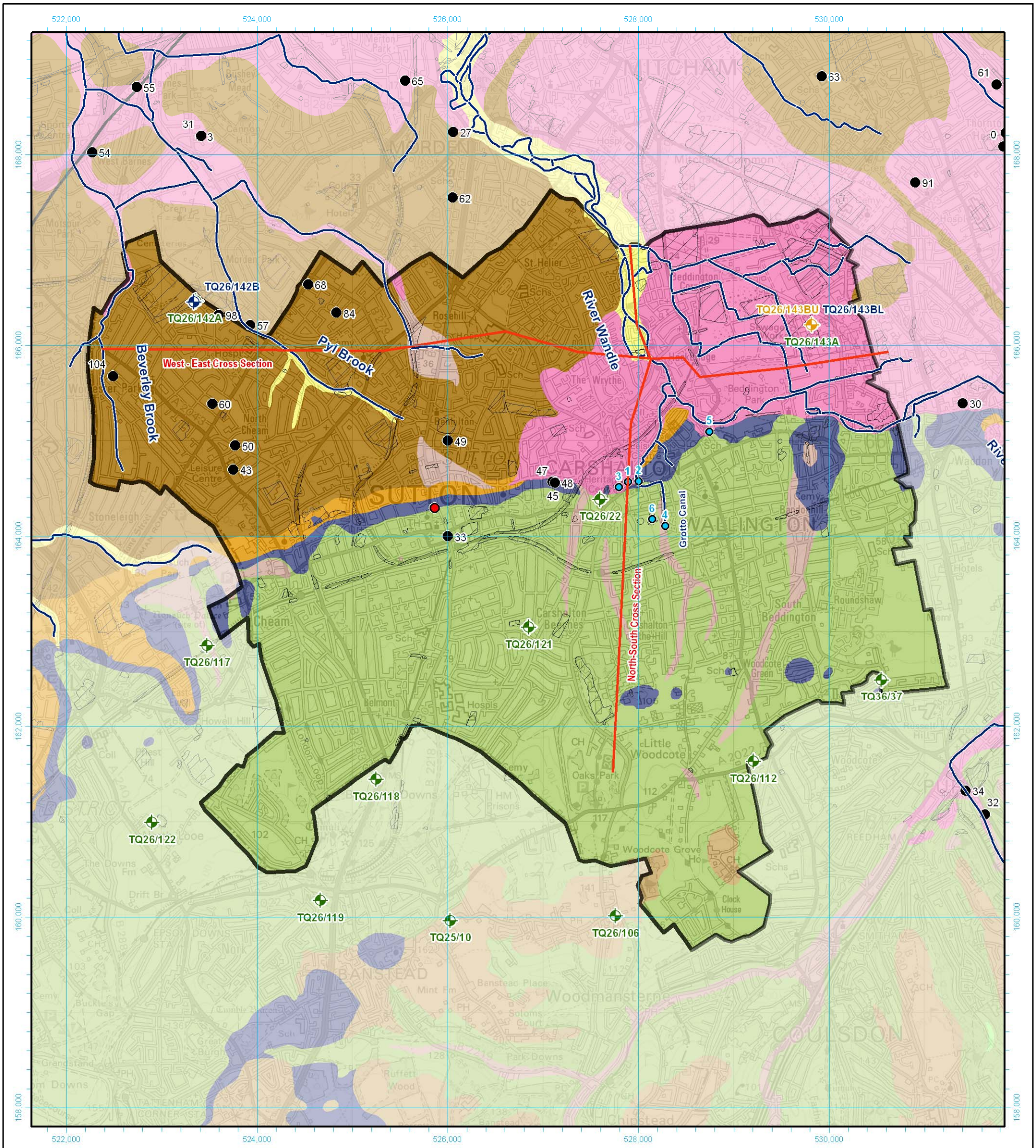
Scale @ A3	Date	Drawn by	Approved
1:30,000	Mar 2010	SL	EB

Main Rivers and Fluvial Flooding Incidents in July 2007

Scott Wilson
6-8 Greencoat Place
London, SW1P 1PL
Tel: (020) 7798 5000

Scott Wilson

FIGURE 06



Legend

- EA Groundwater Flooding Records
- Sutton Council Groundwater Flooding Record
- Spring Location

Environment Agency Observation Boreholes

- Chalk Formation
- Thanet Sand Formation
- Lambeth Group Formation

Solid Geology

- Bagshot Formation
- Claygate Member (Sand, Silt & Clay)
- London Clay Formation
- Harwich Formation
- Lambeth Group (Clay, Silt & Sand)
- Thanet Sand Formation
- Upper Chalk Formation
- Middle Chalk (Undifferentiated)

Drift Geology

- Head (Clay, Silt, Sand & Gravel)
- Clay with Flints Formation (Clay, Silt, Sand & Gravel)
- Peat
- Alluvium (Clay, Silt, Sand & Gravel)
- River Terace Deposits
- Disturbed Blackheath Beds (Sand & Gravel)
- Headley Heath Member (Sand & Gravel)
- Sand & Gravel of uncertain age and origin

- Line of Cross Section
- Council Administrative Area
- Fault
- Landscaped, Made, Worked & Infilled Ground

NOTES

The term 'Middle Chalk' is no longer in formal use, and is replaced by the 'Holywell Nodular Chalk Formation' and the 'New Pit Chalk Formation'. However, the new units are undifferentiated within this area.

The term 'Upper Chalk' is no longer in formal use, and the unit has been split into several formations including the 'Lewes Nodular Formation', 'Seaford Chalk Formation', 'Newhaven Chalk Formation' and 'Culver Chalk Formation'. However, the new units are undifferentiated within this area.

Project Title

Sutton Surface Water Management Plan

FIGURE 7

Scale at A3: 1:40,000

Drawing Title

Geological Map

Drw:	App:	Rev:
Ryan Cox	Steve Cox	1
Chk: Steve Cox	Date: 07.04.10	

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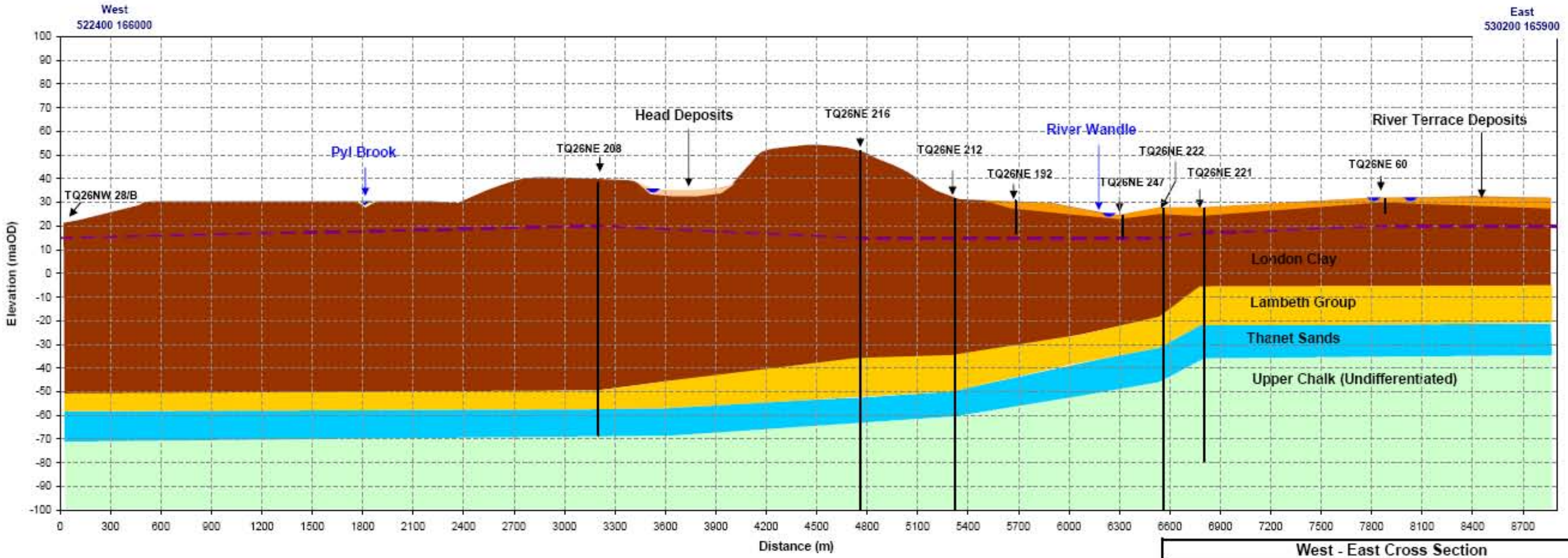
File location: K:\jobs\D128030 Sutton SWMP (Phase 1 & 2)\700 Technical\711 GIS\01 Layout



West - East Cross Section

D128030 | Figure 8

Drawn By	Date	Approved	Date
C.Woolhouse	05/03/2010	S. Cox	24/03/2010

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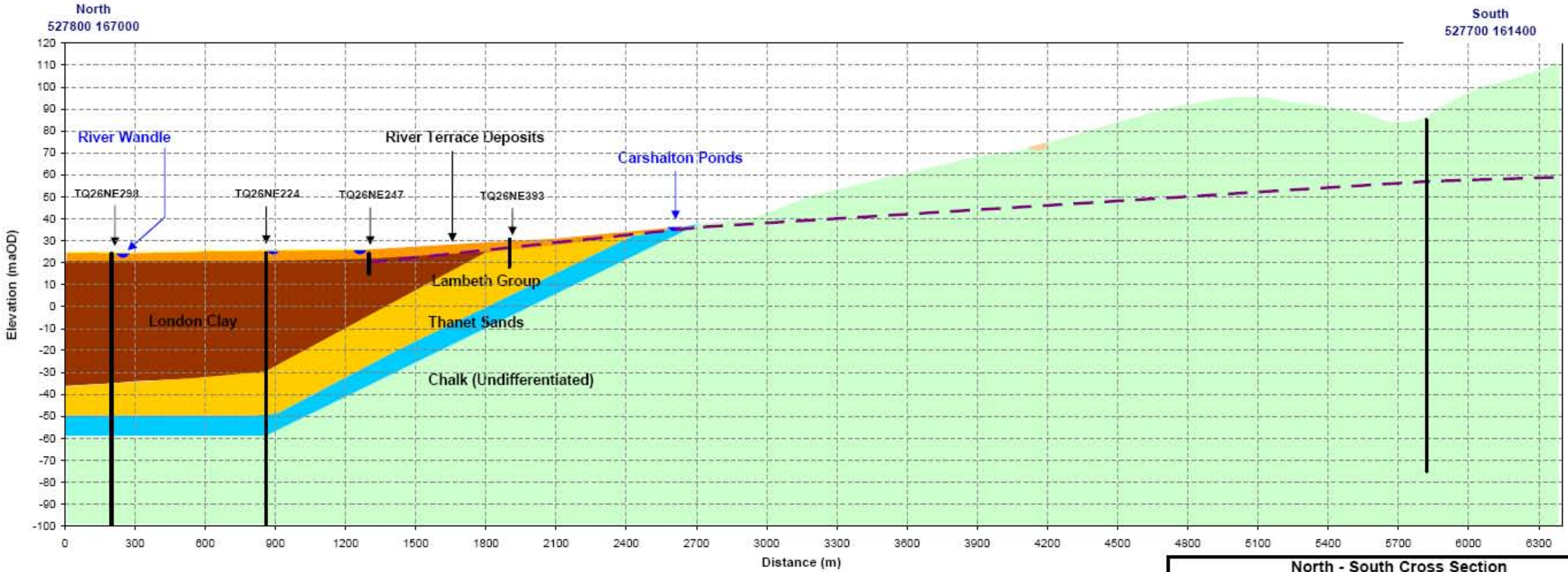
Basingstoke, Hampshire RG21 7PP
Telephone: (01256) 310200

File :\jobs\D128030 Sutton\700 Technical\701 Data\Site Cross Sections V2_West_East_Final



Chalk Piezometry - January 2001

Groundwater Flow to the North

File :\jobs\D128030 Sutton\700 Technical\701 Data\Site Cross Sections V2_North_South_DRAFT

North - South Cross Section

D128030			Figure 9
Drawn By	Date	Approved	Date
C.Woolhouse	22/03/2010	S. Cox	26/03/2010

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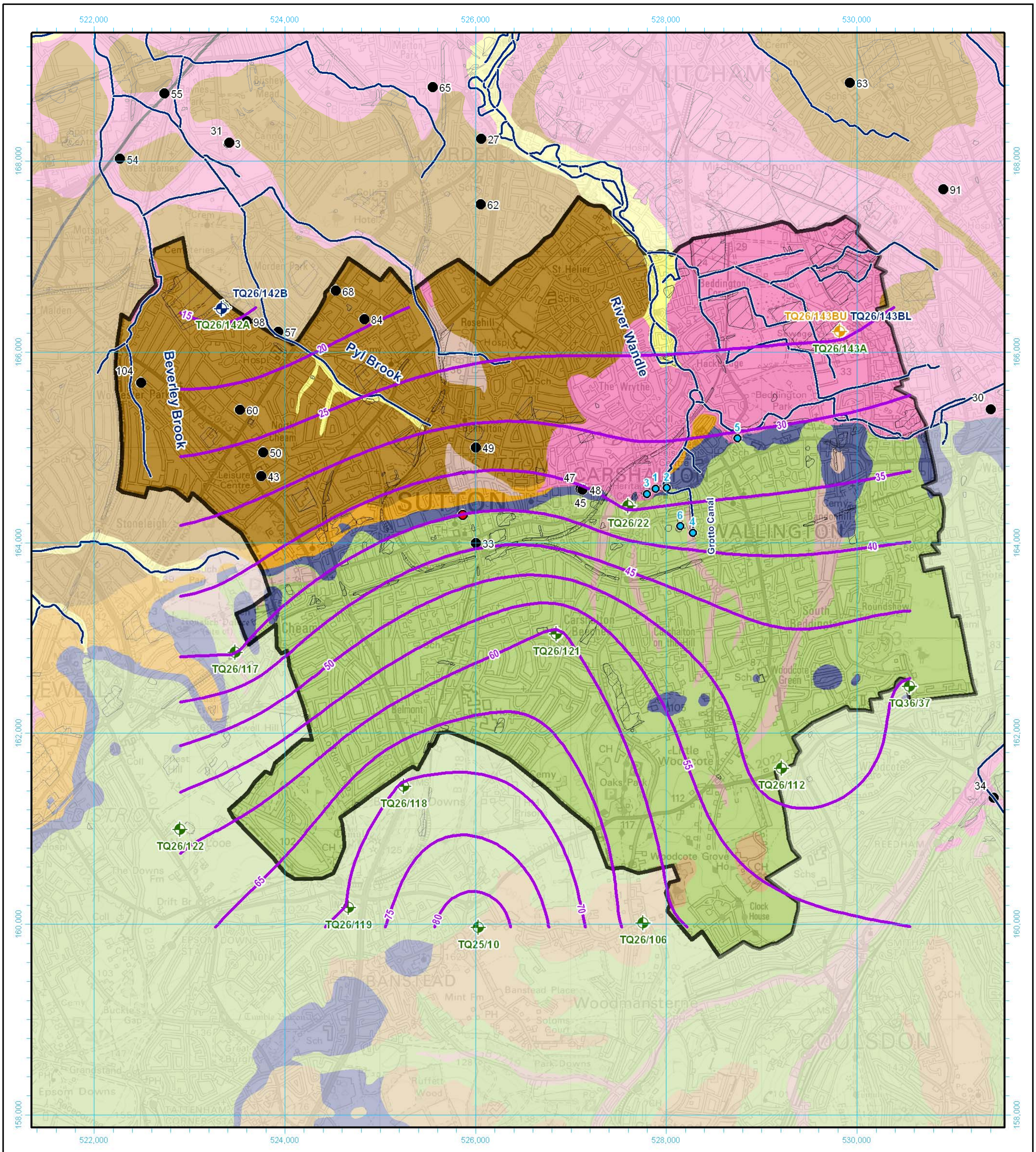


Legend

- Spring Location
- Sutton Council Groundwater Flooding Record

Environment Agency Observation Boreholes

- Chalk Formation
- Thanet Sand Formation
- Lambeth Group Formation
- EA Groundwater Flooding Records

Solid Geology

- Bagshot Formation
- Claygate Member (Sand, Silt & Clay)
- London Clay Formation
- Harwich Formation
- Lambeth Group (Clay, Silt & Sand)
- Thanet Sand Formation
- Upper Chalk Formation
- Middle Chalk (Undifferentiated)

Drift Geology

- Head (Clay, Silt, Sand & Gravel)
- Clay with Flints Formation (Clay, Silt, Sand & Gravel)
- Peat
- Alluvium (Clay, Silt, Sand & Gravel)
- River Terace Deposits
- Disturbed Blackheath Beds (Sand & Gravel)
- Headley Heath Member (Sand & Gravel)
- Sand & Gravel of uncertain age and origin

- Chalk Groundwater Levels (January 2001)
- Council Administrative Area
- Fault
- Landscaped, Made, Worked & Infilled Ground

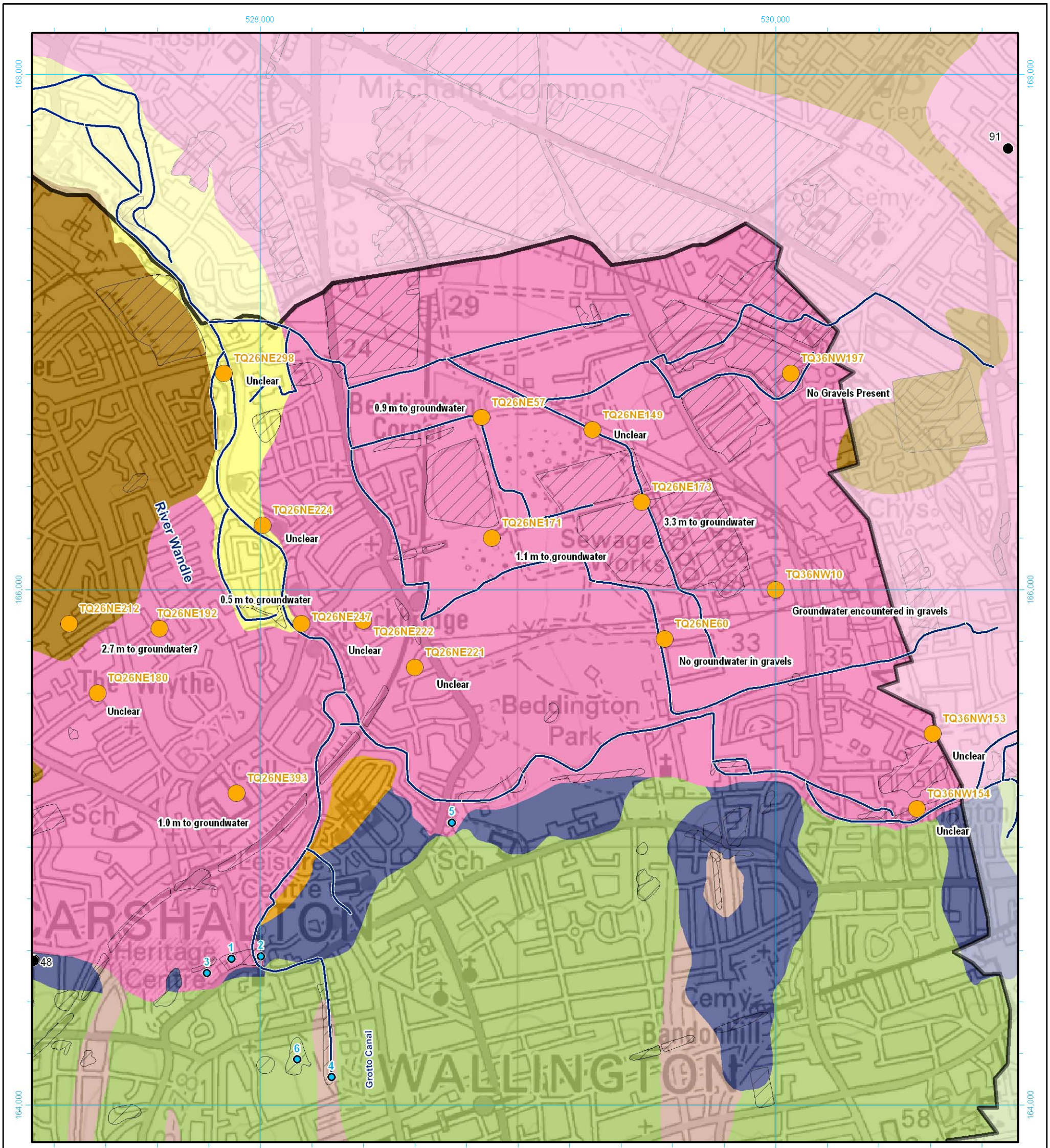
NOTES

The term 'Middle Chalk' is no longer in formal use, and is replaced by the 'Holywell Nodular Chalk Formation' and the 'New Pit Chalk Formation'. However, the new units are undifferentiated within this area.

The term 'Upper Chalk' is no longer in formal use, and the unit has been split into several formations including the 'Lewes Nodular Formation', 'Seaford Chalk Formation', 'Newhaven Chalk Formation' and 'Culver Chalk Formation'. However, the new units are undifferentiated within this area.

Project Title: **Sutton Surface Water Management Plan**	**FIGURE 10**		Scott Wilson Scott House, Alencon Link, Basingstoke, Hants, RG21 7PP Telephone (01256) 310 200 www.scottwilson.com
	Scale at A3: 1:40,000		Copyright
Drawing Title: **Chalk Groundwater Levels (January 2001)**	Drw: Chris Woolhouse	App: Steve Cox	Rev: 1
	Chk: Steve Cox	Date: March 2010	

File location: K:\jobs\D128030 Sutton SWMP (Phase 1 & 2)\700 Technical\711 GIS\01 Layout



Legend

- Spring Location
- Sutton Council Groundwater Flooding Record
- EA Groundwater Flooding Records
- Borehole Log
- Council Administrative Area
- Fault
- Landscaped, Made, Worked & Infilled Ground

Solid Geology

- Bagshot Formation
- Claygate Member (Sand, Silt & Clay)
- London Clay Formation
- Harwich Formation
- Lambeth Group (Clay, Silt & Sand)
- Thanet Sand Formation
- Upper Chalk Formation
- Middle Chalk (Undifferentiated)

Drift Geology

- Head (Clay, Silt, Sand & Gravel)
- Clay with Flints Formation (Clay, Silt, Sand & Gravel)
- Peat
- Alluvium (Clay, Silt, Sand & Gravel)
- River Terace Deposits
- Disturbed Blackheath Beds (Sand & Gravel)
- Headley Heath Member (Sand & Gravel)
- Sand & Gravel of uncertain age and origin

NOTES

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The term 'Upper Chalk' is no longer in formal use, and the unit has been split into several formations including the 'Lewes Nodular Formation', 'Seaford Chalk Formation', 'Newhaven Chalk Formation' and 'Culver Chalk Formation'. However, the new units are undifferentiated within this area.

Project Title

Sutton Surface Water Management Plan

FIGURE 11

Scale at A3: 1:15,000

Drawing Title

River Terrace Gravel BGS Log Water Level Information

Drw:	App:	Rev:
C. Woolhouse	S. Cox	1
Chk:	Date:	Date:
S. Cox	March 2010	March 2010

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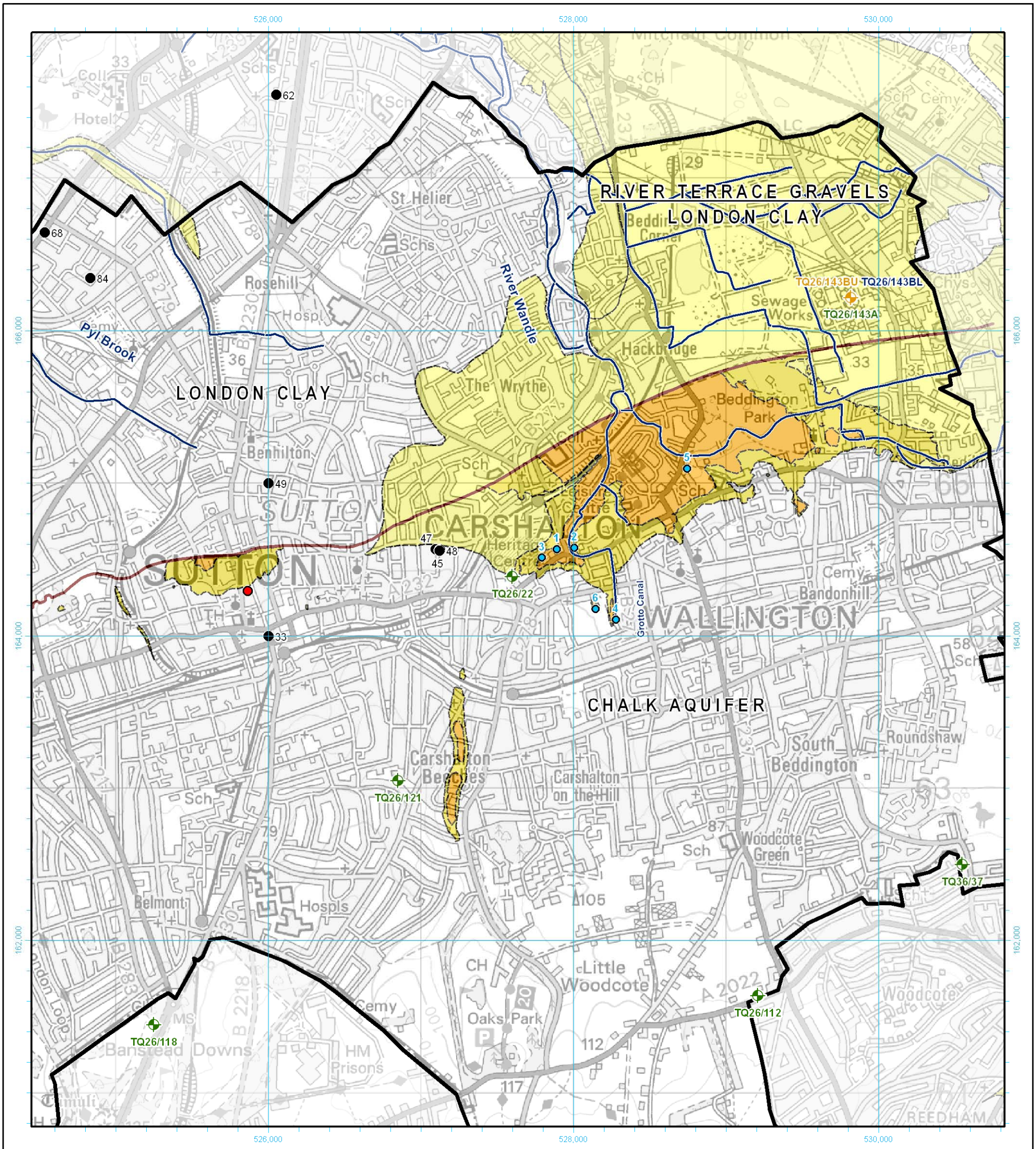
File location: K:\jobs\D128030 Sutton SWMP (Phase 1 & 2)\700 Technical\711 GIS\01 Layout



Legend

- Spring Location
- EA Groundwater Flooding Records
- Sutton Council Groundwater Flooding Record

Environment Agency Observation Boreholes

- Chalk Formation
- Thanet Sand Formation
- Lambeth Group Formation

- London Clay Outcrop Boundary

Potential Drift Groundwater Flood Risk Areas

- River Terrace Deposits

Potential Chalk Groundwater Flood Risk Areas

- Jan 2001 Chalk Groundwater Table < 4 m below Ground level
- Jan 2001 Chalk Groundwater Table < 2 m below Ground level

Project Title	**Sutton Surface Water Management Plan**	**FIGURE 12**	
		Scale at A3: 1:25,000	
Drawing Title	**Potential Groundwater Flood Risk Areas**	Drw: S. Cox / App: S. Cox / Rev: 1	
		Chk: M. Graham / Date: March 2010	

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File location: K:\jobs\D128030 Sutton SWMP (Phase 1 & 2)\700 Technical\711 GIS\01 Layout

Appendix D: Intermediate Pluvial Modelling Figures

Figure 01	London Borough of Sutton	Surface Water Depth Grid 75yr Event
Figure 02	London Borough of Sutton	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 03	North Cheam	Surface Water Depth Grid 75yr Event
Figure 04	North Cheam	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 05	Sutton Town Centre North	Surface Water Depth Grid 75yr Event
Figure 06	Sutton Town Centre North	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 07	Sutton Town Centre South	Surface Water Depth Grid 75yr Event
Figure 08	Sutton Town Centre South	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 09	Carshalton	Surface Water Depth Grid 75yr Event
Figure 10	Carshalton	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 11	Wallington	Surface Water Depth Grid 75yr Event
Figure 12	Wallington	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 13	Hackbridge South	Surface Water Depth Grid 75yr Event
Figure 14	Hackbridge South	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 15	Hackbridge North	Surface Water Depth Grid 75yr Event
Figure 16	Hackbridge North	Surface Water Depth Grid 100 yr Event + Climate Change
Figure 17	Worcester Park	Surface Water Depth Grid 75yr Event
Figure 18	Worcester Park	Surface Water Depth Grid 100 yr Event + Climate Change