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Drainage of development sites – a guide

R May

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SUMMARY

The guide is intended to assist all those involved with the foul and surface water drainage of development sites. It is specifically aimed at developments in the UK based on national requirements and international best technical practice. It provides guidance:

- on the approach needed to obtain Town and Country Planning Act (T&CPA) consent
- to developers and consultants on current good engineering practice for design of drainage and sewerage for new sites
- on the issues affecting site drainage
- on hydraulic-related engineering issues
- to key industry documents.

An important output of recent HR Wallingford research is a proposed new methodology for calculating site storage.

It is intended that general engineering practitioners, developers and architects will use this document as a first point of reference for guidance and information on all aspects related to the hydraulics of site drainage. Sites range from small suburban developments to large industrial estates, each having specific features that require particular attention.

Drainage of development sites – a guide

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This guide has been brought to the industry by HR Wallingford with financial support from the DETR and the Environment Agency and expert guidance from a steering group drawn from all parts of the water industry. It has been clear for some time that there are several aspects of site drainage that give rise to confusion and uncertainty. They include roof drainage, site pipe design, both foul and surface water, and site storage, as well as sustainable drainage methods. All are covered by this guide, which aims to help the developer or general practice engineer take the correct approach when designing site drainage. The guide is specifically aimed at developments in the UK based on national requirements and international best technical practice.

Author

Richard Kellagher is a chartered civil engineer specialising in urban drainage computational modelling and research into sustainable drainage.

Experience in supporting both large and small developers with their drainage issues led to an awareness for the need for a site drainage guide together with research into related matters, such as stormwater drainage, which became a major issue in the 1990s. He has been responsible for several research projects on sustainable urban drainage systems and has assisted the Environment Agency in providing easy-to-use guidance on stormwater requirements for new developments. Other interesting research projects include a sewerage rehabilitation manual for the EU and the revision of the Wallingford Procedure.

This project was led by Richard Kellagher of HR Wallingford with contributions from Manuela Escarameia. Assistance and guidance was also provided by the following industry experts:

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GLOSSARY

Adoption of sewers	The transfer of responsibility for the maintenance of a system of sewers to a sewerage undertaker.
Aesthetic pollution	Solid sewage-related materials that are visible but create little environmental impact.
Antecedent conditions	The condition of a catchment before a rainfall event.
Antecedent precipitation	The relevant rainfall that takes place before the point in time of interest.
Antecedent precipitation index	Expressed as an index determined by summation of weighted daily rainfalls for a period preceding the start of a specific event.
Anti-flooding device	A device specifically designed to be installed in gravity drains or sewers to prevent backflow from a sewer towards a property or group of properties.
Areal reduction factor	A factor applied to point rainfall depths or intensities to generate values applicable to an area.
Attenuation	The reduction in peak discharge of a flood wave accompanied by an increase in duration of increased flow.
Balancing pond	A pond constructed for the purpose of temporary storage of stream flow or surface runoff, which releases the stored water at a controlled rate.
Base flow	Sustained or dry-weather flows not directly generated by rainfall. It commonly constitutes flows generated by domestic and industrial discharge and also infiltration.
Best management practices	Structural and non-structural measures used to store or treat urban surface water runoff to reduce flooding, remove pollution and provide other amenities.
Brownfield site	Redevelopment of a site, often associated with pollution issues.
Catchment	A defined area, often determined by topographic features or land use, within which rain will contribute to runoff to a particular point under consideration.
Cavitation	The process of implosion of air in water that is a function of high velocities, which causes damage.
Colebrook-White equation	An empirical equation relating flow to roughness and gradient of the conduit and the viscosity of the fluid.
Collection system	In wastewater, a system of conduits, generally underground pipes, which receives and conveys sanitary wastewater (domestic and/or industrial) and/or stormwater.
Combined network	A sewer network that collects rainfall from impervious surfaces and foul water from domestic and industrial sources.
Combined sewage	Sanitary or foul sewage mixed with surface water. Also referred to as storm sewage.

Combined sewer	A sewer intended to receive both surface runoff and wastewater (domestic and industrial).
Combined sewer overflow (CSO)	A structure on a combined or partially separate sewer system that allows flows above the sewer pass-forward capacity to be discharged to another sewer, a stormwater retention tank, a watercourse, or to another disposal point.
Consented discharges	Term used in the UK for discharges meeting the conditions imposed by the appropriate public authority for potentially polluting flow to a watercourse or into the ground.
Contributing area	The area of the catchment that contributes storm runoff directly to the sewerage system.
Control structure	A hydraulic device to limit the rate of the flow.
Culvert	A covered channel or pipeline (defined by the Highway Agency as wider than 900 mm).
Depression storage	Natural depressions on the surface of the ground that need to be filled by rainfall before runoff can take place.
Design storm	A synthetic rainfall event of a given duration and return period. It has been derived by statistically analysing a historical series of rainfall events for a specific location.
Detention basin	A basin constructed for the purpose of temporary storage of stream flow or surface runoff, which releases the stored water at controlled rates.
Detention tanks (balancing tanks)	Tanks constructed in a sewerage system to store a volume of water temporarily during peak flows (see off-line and on-line tanks).
Discharge	The volume of liquid flowing through a cross-section of conduit per unit of time.
Discharge coefficient	A coefficient, derived by experiment, applied in a formula by which the theoretical discharge of a fluid through an orifice, weir or nozzle can be correctly calculated.
Domestic (foul) wastewater	Wastewater from household services including outflows from sinks, toilets, washing machines etc.
Drain	A pipeline, usually underground, designed to carry wastewater and/or surface water from a source to a sewer; a pipeline carrying land drainage flows or surface water from a highway.
Drainage	A collection of pipes, channels and other engineering works designed to convey stormwater away from a built-up environment.
Dry weather flow (DWF)	The flow of wastewater in a sewer during dry weather. The flow consists of sewage and infiltration.
Effluent	Wastewater or other liquid, partially or completely treated, or in its natural state, flowing out of a pipe or treatment plant.
Erosion	Detachment and movement of soil or sedimentary deposits by the flow of water, such as over the ground surface or in a pipe or channel.

Eutrophication	The progressive enrichment of surface waters, particularly non-flowing bodies of water, such as lakes and ponds, with dissolved nutrients, such as phosphorus and nitrogen compounds, which accelerates the growth of algae and higher forms of plant life.
Evaporation	The drying out process of the ground surface, which constitutes a minor part of the losses taken account in rainfall-runoff loss models.
Event (rainfall)	Single occurrence of a rainfall period before and after which there is a sufficient dry period to define its effect on the sewer system.
Extreme event	Single occurrence of an event that is likely to occur very infrequently (eg long drought or big storm etc).
First foul flush	The initial discharge of active sediments and pollutants generally higher than the average concentration of pollutants caused by rainfall.
Flap gate	A gate that opens to let water out but prevents water entering back into a system.
Flood storage pond	A pond constructed for the purpose of temporary storage of stream flow or surface runoff, which releases the stored water at controlled rates.
Flood studies report	Landmark report in UK for catchment hydrology (Institute of Hydrology, 1975).
Flow regime	The typical variation of discharge of a waterway usually over an annual or seasonal period.
Foul sewage	Waterborne waste of domestic or industrial origin excluding rainwater and surface water.
Foul system	A drain or sewer system that has been designed to carry only foul sewage.
French drain/filter drain	The use of a granular trench filled with stone to convey and infiltrate stormwater runoff.
Frequency	The number of occurrences of a certain phenomenon per unit time.
Gradient	The angle of inclination (of pipe), which dictates its capacity and velocity of flow.
Gravity system	A drain or sewer system where flow is caused by the force of gravity and where the pipeline is designed normally to operate partially full.
Greenfield/greenfield site	New development, usually at the periphery of existing urban areas. This creates increased rainfall-runoff and has an impact on existing sewer systems and watercourses.
Greywater	Wastewater from baths and hand basins; sometimes also taken to include wastewater from washing machines and kitchen sinks.
Gross solids	Solids, usually organic in nature, either floating, suspended or deposited, which have a polluting effect on the receiving water. Often restricted to visible solids with one dimension greater than 25 mm.

Groundwater Subsurface water occupying the saturation zone from which wells and springs are fed. In a strict sense, the term applies only to water below the water table.

Gully A structure to permit the entry of surface runoff into the sewer system. It is usually fitted with a grating and a grit trap.

Head-discharge The relationship between a discharge rate and the water level causing that discharge.

Highway Any road, track, bridleway or public footpath in private or public ownership that is not associated with an individual property.

Highway drainage system A drain or sewer system constructed for the purpose of draining a highway.

Hydraulic analysis Assessment of the hydraulic behaviour of a system. Simulation hydraulic modelling of a sewerage network to determine its performance.

Hydraulic capacity The maximum flow that a pipe of given dimensions, slope and roughness can carry (often quoted as pipe-full capacity, which is a little less than the maximum capacity).

Hydraulic performance The measure of the capacity of the system or part thereof.

Hydraulic simulation The computational process carried out by a computer model to analyse the behaviour of a system (sewer network) due to an external influence (rainfall).

Hydrograph A graph showing, for a given point on a stream or conduit, the discharge, stage, velocity, available power or other property of water with respect to time.

Impermeable surface Surface that resists the infiltration of water. Usually a measure of roof and road surfaces in simulation modelling.

Industrial discharge Outflow from an industrial unit, which varies enormously depending on the processes carried out in the factory.

Infiltration

(a) The unintended ingress of groundwater into a drainage system (also termed parasitory flow in some countries)
(b) the introduction of rainwater runoff into the ground.

Infiltration (to sewer) The ingress of groundwater into a drain or sewer system through defects in pipes, joints or manholes.

Inflow Flow which enters the sewer; this can be generated by rainfall or an industrial discharge or other particular connection.

Initial loss In hydrology, rainfall preceding the beginning of surface runoff. It includes interception, surface wetting and infiltration.

Inlet

(1) A connection between the catchment area and a drain or sewer for the admission of surface or stormwater.
(2) A structure at the entrance end of a conduit.
(3) The upstream end of any structure through which water may flow.

Inspection chamber A structure that offers access to the drain or sewer for servicing by means of equipment remotely operated from ground level; no personal access.

Intensity-duration-frequency	The relationship between rainfall intensity (amount per unit of time), rainfall duration (total time over which rainfall occurs) and frequency (return interval) at which the specific intensity-duration relationship is expected to recur.
Interception	The process by which rainfall may be prevented from reaching the ground, for example by vegetation.
Internal drainage boards	Manage ordinary watercourses in areas known as internal drainage districts.
Invert	The floor, bottom or lowest portion of the internal cross-section of a closed conduit.
Land use	Catchments zoned based on economic, geographic or demographic use of land, such as residential, industrial, agricultural, commercial.
Lateral	A private drain or sewer that carries drainage flows from a property to a public sewer.
Lloyd-Davies method	An adaptation by Lloyd-Davies of the Rational Method for storm drainage design.
Major system	In the context of major and minor drainage, this refers to the route followed by storm runoff when the minor system is either inoperative or inadequate. It generally refers to roads and major above ground drainage channels.
Manhole	A structure that provides access for personnel to the drain or sewer for servicing.
Mannings equation	An equation developed by Manning to relate flows in conduits to their size, shape, the gradient and the conduit roughness.
Minor system	The drainage pipes, roadway channels, enclosed conduits and roof connections designed to convey runoff from "normal" storms, to eliminate or minimise inconvenience in the area to be developed. See Major system.
Misconnection	An incorrect connection of an inlet or drain to a drain or sewer that is not designed to carry that element of flow (eg foul sewage entering a surface water system or surface water entering a separate foul system).
Model	A series of mathematical equations in a computer developed and used with the aim of replicating the behaviour of a system.
Modified Rational Method	A modification of the Lloyd-Davies method introduced by the Wallingford Procedure whereby the coefficient of runoff was split into two entities (HR Wallingford and Institute of Hydrology, 1981b).
Monitoring	The procedure of measuring effluent characteristics such as flows or pollutants by means of instruments.
Muskingum-Cunge routeing method	A method of routeing flows in channels and pipes, first applied on the Muskingum River in the USA and subsequently modified by Cunge.
Network	In the context of sewers, a collection of connected nodes and links, manholes and pipes.
Off-line tank	Detention tank that is off the normal path of flow in a network, which comes into operation during periods of high flows.

On-line tank	A detention tank through which the flow of sewage is normally conveyed.
Orifice	A constriction in a pipeline to control the rate of flow.
Outfall	The point, location or structure where wastewater or drainage discharges from a pipe, channel, sewer, drain or other conduit.
Overflow	The intentional or unintentional discharge of sewage to the environment prior to treatment.
Overflow weir	Any device or structure over which any excess water or wastewater beyond the capacity of the conduit or container is allowed to flow
Overland flow	The flow of water over the ground or paved surface before it enters some defined channel or inlet, often assumed to be shallow and uniformly distributed across the width.
Peak discharge	The maximum flow rate at a point in time at a specific location resulting from a given storm condition.
Peakedness	A measure of the sharpness of a rainfall profile; that is, the ratio of the maximum to the mean rainfall intensity.
Peaking factor	The multiple of dry weather flow used for design of pipe sizes and gradients.
Percentage runoff	The percentage of the rainfall volume falling on a specified area that enters the stormwater drainage system.
Percentile	The percentage of occurrences within a stated range; also applied to rainfall profiles (see Peakedness).
Pervious surface	A type of ground surface that allows infiltration of water, although some surface runoff may still occur.
Point rainfall	Rainfall rate at a location, in contrast to the average for the region or a surrounding area.
Pollutant	Dissolved or particulate material washed into and through sewers. Pollutants when discharged into receiving waters cause an adverse environmental impact.
Pollution	The addition to a natural body of water of any material that diminishes the optimal use of the water body by the population which it serves, and that has an adverse effect on the surrounding environment.
PR equation	Usually refers to the Wallingford Procedure runoff equation (HR Wallingford and Institute of Hydrology, 1981a).
Primary treatment	The first major treatment in a wastewater treatment facility, usually sedimentation.
Private sewer	A sewer for which responsibility is not vested with the sewerage undertaker. It is generally collectively owned and maintained by the owner(s) of the building(s) it serves.

Public sewer	A sewer for which responsibility is vested with the sewerage undertaker to maintain it.
Pumping station	A structure containing pumps and appurtenant piping, valves and other mechanical and electrical equipment for pumping water, wastewater, or other liquids.
Rainfall intensity	Amount of rainfall occurring in a unit of time, generally expressed in millimetres per hour (mm/h).
Rainfall profile	A series of values of rainfall intensity varying with time; a rainfall event is referred to as a hyetograph.
Raingauge	An instrument used to measure and record the amount of rainfall at an allocated location.
Rational Method	A simple method, used throughout the world, for calculating the peak discharge in a drainage system for pipe sizing.
Reach (river)	A stretch of river between two points, often used where the river characteristics are similar.
Receiving waters	Water body (river or lake) that receives flow from point or non-point sources such as combined sewer overflows.
Regulator	(1) A structure installed in a sewer, conduit or channel to control the flow of water or wastewater at an intake, or overflow or to control the water level along a canal, channel or treatment unit. (2) The term used in UK to refer to the Environment Agency and OFWAT due to their legal involvement in controlling water companies.
Reservoir storage	The phenomenon by which a volume of flow is stored temporarily on a surface or in a length of pipe or channel as the depth and rate of flow increase; the storage is depleted after the peak of the storm passes.
Retention pond	A pond constructed for the temporary storage of surface water runoff, which releases the stored water at controlled rates.
Return period	The reciprocal of the average annual probability of exceedence of a specific flow value or event.
Runoff	Water from precipitation that flows off a surface to reach a drain, sewer or receiving water.
Runoff coefficient	The proportion of total rainfall that appears as total runoff volume after subtracting depression storage, infiltration and interception.
Saint Venant equation	An equation developed in the 19th century by a French mathematician, which takes account of all the physical processes of fluid flow such as momentum and inertia to calculate depth for gradually varying flow states.
Screen	A device with openings, generally of uniform size, used to retain or remove suspended or floating solids in flowing water or wastewater.

Scumboard	A board or plate that dips below the top water level to retain scum and other floatables.
Sediment concentration	The ratio of the weight of the sediment in a water-sediment mixture to the total weight of the mixture. Sometimes expressed as the ratio of the volume of sediment to the volume of mixture.
Sediment transport	The movement of solids transported in any way by a flowing liquid.
Sedimentation	The process of deposition and consolidation of suspended material carried by water, wastewater or other liquids, by gravity.
Self-cleansing (velocity)	The minimum velocity in sewers necessary to keep solids in suspension, thereby preventing their deposition and subsequent nuisance from blockages or reduced capacity.
Separate system	A drain or sewer system, normally of two pipelines, one carrying wastewater and the other surface water.
Septic tank	A structure for the collection and partial treatment of sewage.
Sewage	Wastewater and/or surface water conveyed by a drain or sewer.
Sewer	A pipe or conduit that carries wastewater or drainage water serving more than one property
Sewer flooding	The unintentional escape of sewage from a sewerage system; the inability of drainage flows to enter a sewerage system because of surcharging.
Sewerage system	A network of pipelines and ancillary works that conveys wastewater and/or surface water from drains to a treatment works or other place of disposal.
Sewerage	Alternative term for "drainage collecting system" for foul and surface water systems.
Sewerage undertaker	An organisation with the legal duty to provide sewerage services in an area. In England and Wales these services are provided by ten water service companies, in Scotland by three water authorities, and in Northern Ireland by the Water Service of the Department of the Environment for Northern Ireland.
Side weir	A diverting weir constructed on the side of a channel or conduit, usually at right angles to the centre-line of the main channel.
Silt	Sediment (often soil) consisting of particles between 0.002 mm and 0.02 mm in equivalent diameter.
Simulation	The representation of specific conditions during a specific period in a sewerage system, treatment works, river etc, by means of a computer model.
Simulation model	The representation of physical system and its time-related behaviour by a computer model.
Sluice gate	A gate constructed to slide vertically and fastened into or against masonry of dams, (penstock) tanks, or other structures under which flow takes place when open.

Soakaway	A pit into which surface water is drained to infiltrate into the ground.
Soffit	The top of the inside of a pipe or conduit.
Soil moisture deficit (SMD)	A measure of soil wetness, calculated by the Meteorological Office in the UK, to indicate the capacity of the soil to absorb rainfall.
Source control	The practice of reducing runoff and also pollutants at their source so that they do not enter the drainage system or become significantly delayed and attenuated.
Spill event	A period when an overflow discharges to a watercourse.
Spill frequency	The number of spill events over a given period.
Stilling pond	A small basin into which flow is discharged, which is used to either dissipate energy or trap solids.
Storage	The impounding of water, either in surface or in underground reservoirs.
Storm	An occurrence of a meteorological event, often of rainfall, snow or hail. Used in connection with a phenomenon that is either unusual or of great magnitude, rate or intensity.
Storm tanks	Storage tanks designed to hold most of the stormwater in either sewers or treatment works such that downstream flooding or incomplete treatment respectively is minimised.
Stormwater overflow	A weir, orifice or other device for permitting the discharge from a combined sewer of the flow in excess of that which the sewer is designed to carry.
Sub-catchment	The ground surface area drainage directly to one gully or a collection of gullies.
Surface washoff	The process whereby the rainfall runoff carries surface sediments and dissolved pollutants into the drain or sewer system.
Surface water	Water from precipitation that has not seeped into the ground and is discharged to the drain or sewer system directly from the ground or from exterior building surfaces.
Surface water system	A drain or sewer system that has been designed to carry only surface water.
Suspended solids	Insoluble solids that either float on the surface of, or are in suspension in, water, wastewater or other liquids.
Sustainable drainage	The application of drainage techniques that are considered to be environmentally beneficial, causing minimal or no long-term detrimental impact.
Swale	A grass channel for stormwater collection with shallow side slopes, which is normally dry except during rainfall.
Synthetic rainfall	Rainfall depths or intensities derived from rainfall statistics and not representing an individual real rainstorm.

Synthetic rainfall series	Rainfall time series usually derived by stochastic processes for use in place of a recorded rainfall series.
Tank sewer	A length of sewer with a cross-sectional area in excess of that required for the conveyance of the normal sewer flow, the additional volume being used for the storage of storm sewage.
Time of concentration	Time between the start of a runoff event and the time when the entire catchment is contributing flow to a specific point in the network.
Time of entry	The time taken for surface runoff to reach the entry into the pipe system.
Time series rainfall	A continuous or discontinuous record of individual events generated artificially or selected real historical events that are representative of the rainfall in that area.
Urban drainage	Pipe systems and other related structures to serve an urban environment.
Vacuum sewerage system	A system that operates under negative (sub-atmospheric) pressure to evacuate drainage flows from a property or group of properties; the system may consist of one or more vacuum pumps, a central vacuum reservoir, pipework and interface valves.
Vortex overflow	A type of storm overflow that makes use of the spiralling flow in a vortex to retain polluting material within the pipe system.
Wallingford Procedure	A design and analysis procedure for urban drainage networks (HR Wallingford and Institute of Hydrology, 1981a).
Washoff (of pollutants)	The transport of pollutant mass from the catchment surface during a rainfall event.
Wastewater	Water used and discharged to drain.
Water quality	The chemical, physical and biological characteristics of water with respect to its suitability for a particular purpose.
Water quality standards	Standards set by the national legislation or European Community directives and enforced by regulatory authorities in member states.
Water-table	The surface within soil or rock strata at which groundwater saturation occurs.
Water UK	The organisation representing all water supply companies in UK.
Watercourse	A natural or artificial channel for passage of water.
Weir	An overflow structure across a channel that may be used for controlling upstream surface level, or for measuring discharge, or for both; usually horizontal and constructed as either broad- or sharp-crested.
Wet well	The entry chamber in a pumping station from which water is pumped to a higher level.

ABBREVIATIONS

ADAS	Agricultural Development and Advisory Service
AFD	anti-flooding device
API5	antecedent precipitation index (over previous five days)
API30	30-day antecedent precipitation index
BMP	best management practices
BRE	Building Research Establishment
BS	British Standard
BS EN	European Standard for use in Britain (see EN)
BWB	British Waterways Board (trading as British Waterways)
C_r	routeing coefficient - used in the Modified Rational Method
C_v	volumetric coefficient - used in the Modified Rational Method
CDM	Construction (Design and Management) Regulations
CEH	Centre for Ecology and Hydrology
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CIRIA	Construction Industry Research and Information Association
CSO	combined sewer overflow
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions (replaced by ODPM and DEFRA)
DTLR	Department for Transport, Local Government and the Regions
DoE	Department of the Environment (replaced by DETR)
DoE (NI)	Department of the Environment in Northern Ireland
EA	Environment Agency
EN	Europäische Norm (European Standard)
FEH	Flood estimation handbook (CEH, 1999)
FSR	Flood studies report (IH, 1975)

FSSR	Flood studies supplementary reports (IH, 1975-1985)
HA	Highways Agency
HMIP	Her Majesty's Inspectorate of Pollution (replaced by Environment Agency)
HOST	hydrology of soil types
IDB	internal drainage board
IDF	intensity - depth - frequency (relationship)
IF	effective impervious area factor
IH	Institute of Hydrology (replaced by CEH)
MAFF	Ministry of Agriculture, Fisheries and Food (replaced by DEFRA)
M52day	five-year depth of rainfall in two days
M560	five-year 60-minute depth of rainfall
NAPI	New Antecedent Precipitation Index
NERC	National Environment Research Centre
NRA	National Rivers Authority (replaced by Environment Agency)
NT	National Trust
ODPM	Office of the Deputy Prime Minister
OFWAT	Office of Water Services (for England and Wales)
PF	porosity fraction (soil storage depth)
PIMP	percentage impermeable proportion of a catchment contributing to runoff – see PR equation in Glossary
PPG	Planning Policy Guidance (DETR; subsequently ODPM, DTLR)
PPG	Pollution Prevention Guidelines (EA)
PR	percentage runoff
pr EN	provisional EN
RP	return period
SAAR	standard average annual rainfall assessed over a period of years
SEPA	Scottish Environment Protection Agency

SOIL	soil type classification used by FSR (IH, 1975) and The Wallingford Procedure (HR Wallingford and IH, 1981a)
SMD	soil moisture deficit
STW	sewage treatment works
SUDS	sustainable urban drainage system
T&CPA	Town and Country Planning Act 1990
TC	time of concentration
TE	time of entry
T_p	time to peak (FSR measurement)
TRRL	Transport and Road Research Laboratory (now TRL, Transport Research Laboratory)
TSR	time series rainfall
UCWI	Urban Catchment Wetness Index - describes the wetness of the catchment, usually calculated for the start of a rainfall event
UPM	urban pollution management
WASSP	Wallingford Storm Sewerage Package - the first computer package for the design and analysis of sewage networks
WC	water closet
WRAP	winter rainfall acceptance potential; used by The Wallingford Procedure (HR Wallingford and IH, 1981a)
WSA	Water Services Association
WwTW	wastewater treatment works

1 SCOPE

This guide is intended to assist all those involved with drainage for new developments. It is specifically directed at developments in the UK based on national requirements and international best technical practice. It emphasises the need for a structured approach that integrates the determination of the site layout with landscaping, technical design and Town and Country Planning Act 1990 (T&CPA) consents. The objective is to arrive at the most appropriate drainage system for the site.

Guidance is provided on aspects of drainage design that are not widely available elsewhere. In particular, the guide focuses upon the approval process, sustainable techniques and hydraulic calculations.

Virtually all hydraulic aspects of site drainage are covered in sufficient depth to enable the user to take the correct approach and to understand the principles of design and the criteria used. Although it deals primarily with the hydraulic issues of drainage, aspects such as operation, maintenance and construction are also briefly addressed. The guide understands drainage to include both foul and surface water drainage systems.

Site drainage is moving away from the simple provision of pipes, and the guide details a number of options that UK regulators are keen to promote in the drive towards achieving sustainability. Because of this, the importance of entering into discussion with relevant authorities at an early stage is stressed.

It is intended that this guide will be the general practitioner's first reference point for good practice and advice on sources of more detailed information. This should make it easier to obtain T&CPA approval and facilitate the successful adoption of the drainage network.

The guide aims to provide both the breadth of information needed for site drainage design and the specific details of the procedures that developers should follow to ensure drainage is part of an integrated approach to the development plan ning of the site.

1.1 Document structure

The guide starts by looking at planning and drainage in general, before considering technical aspects in detail. These technical chapters are ordered in a top-down sequence, dealing first with roofs and going "downhill" to the site outfall. (Construction is generally carried out in the reverse order.) References are provided to allow more detailed information to be obtained from specialist drainage guides and elsewhere.

The appendices provide additional information on subjects ranging from the roles and responsibilities of regulatory bodies to principles relating to vacuum sewerage. Worked examples are also provided to illustrate the method of approach for designing roof drainage and attenuation storage structures.

A glossary of terms and abbreviations is provided to define the meaning of technical words and phrases.

2 THE T&CPA PROCESS

All projects pass through several stages of design before construction proceeds. Various drainage-related aspects need to be addressed in each phase. Very small developments will not necessarily have to consider all of the issues that need to be addressed by large developments, but they should be specifically omitted rather than merely forgotten. Figure 2.1 illustrates the phased approach and the issues to be considered. Figure 2.3 is a chart produced by the Royal Institute of British Architects (RIBA) that also addresses the construction stage and the CDM aspects of health and safety.

At each of the project phases the following three aspects need to be specifically considered. These are:

- technical issues
- duration of each phase
- T&CPA approval activities.

2.1 T&CPA considerations for the developer

From the area structure plan and local plans produced by county councils and district councils, the developer can see the land that has been allocated for development and the land use category applied. The problem facing developers is that little public information is available for Town and Country Planning Act (T&CPA) guidance on the drainage requirements/limitations for sites. Experienced developers know that it is important to establish what drainage options exist before putting in a T&CPA application, as the cost involved in meeting criteria set by the relevant authority is often considerable.

The Environment Agency provides general guidance in the form of Local Environment Agency Plans (LEAPs), but detailed negotiations are likely to be needed for individual sites. The Agency plays an important role in providing guidance to local authorities for proposed developments.

The option of draining properties to a public sewer, if it exists, can always be taken, as the sewerage undertaker has a legal duty to provide such a service. The receiving capacity of the sewer is often limited, however, and on-site storage is often stipulated. This aspect can only be established by discussion with the sewerage undertaker. Although the highway authority is responsible for road drainage, developments rarely build road drainage separately from pipes serving roof drainage, because this results in a three-pipe system (foul, roof and road) serving the site. Thus surface drains tend to serve both roads and roofs. The main exception to this is where roofs and/or roads are served by soakaways.

If there is no sewer locally, a sewer can be requisitioned. A developer who requests such a sewer has to pay an annual charge for the provision of the sewer for up to 12 years, though a single commuted sum is often agreed to. The basis of this charge is defined under Section 98 of the Water Industry Act, 1991.

The developer is not only interested in securing T&CPA approval for surface water disposal, but is usually concerned to have the sewers “adopted” by the sewerage undertaker or, in some cases, the highway authority. This imposes certain standards of construction, and also constrains the developer to using drainage options that are acceptable to the relevant authority. The authority is usually concerned to minimise long-term maintenance costs, so it is often reluctant to consider options other than a traditional pipe system. This aspect is particularly of concern to the Environment Agency and similar bodies that are trying to apply more environmentally beneficial solutions to site drainage. Sustainable urban drainage systems are detailed in CIRIA publications C521 and C522 (Martin et al, 2000a and b).

The T&CPA process is illustrated in Figure 2.2.

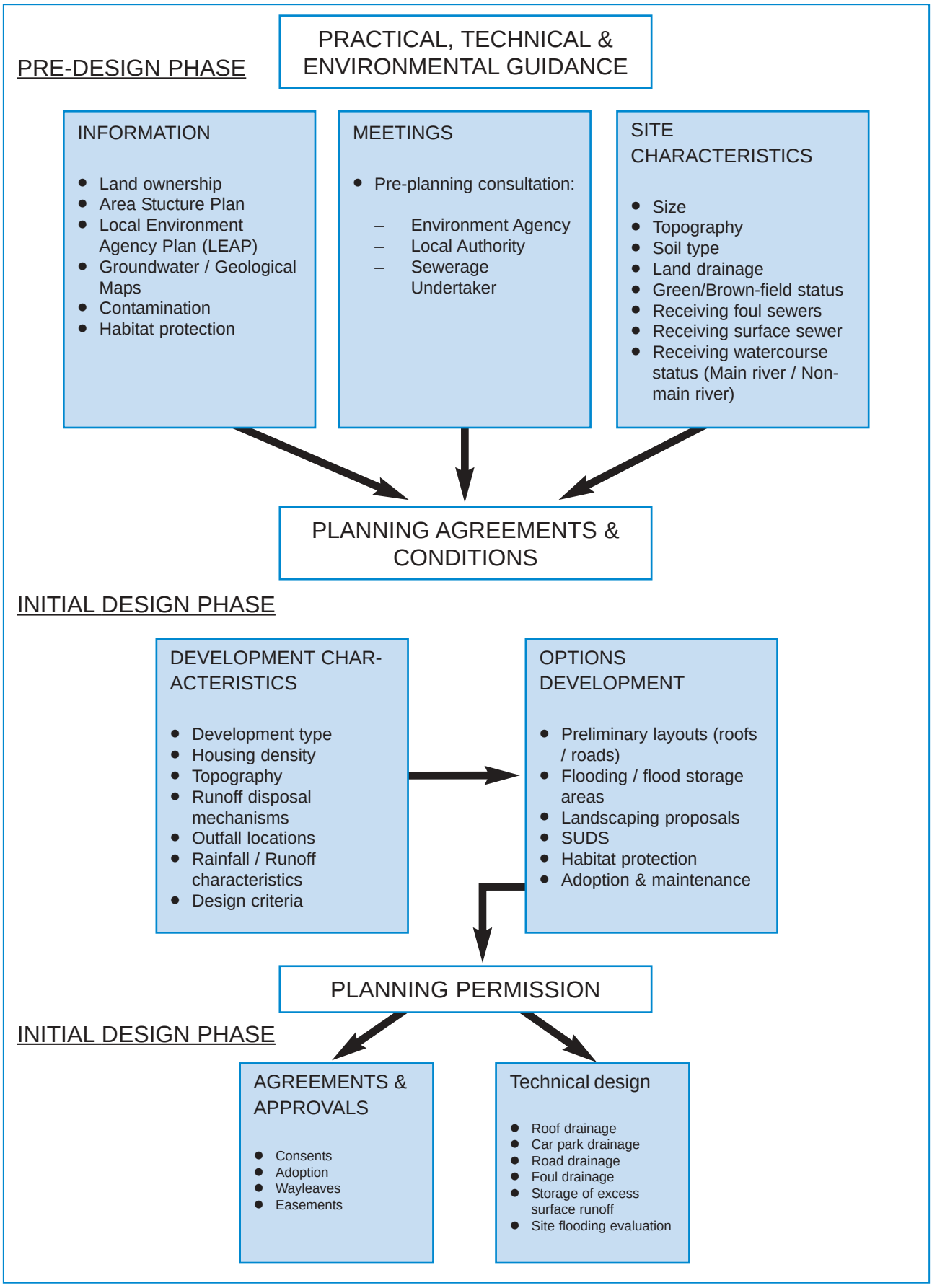

Figure 2.1 *Integrated phased design*

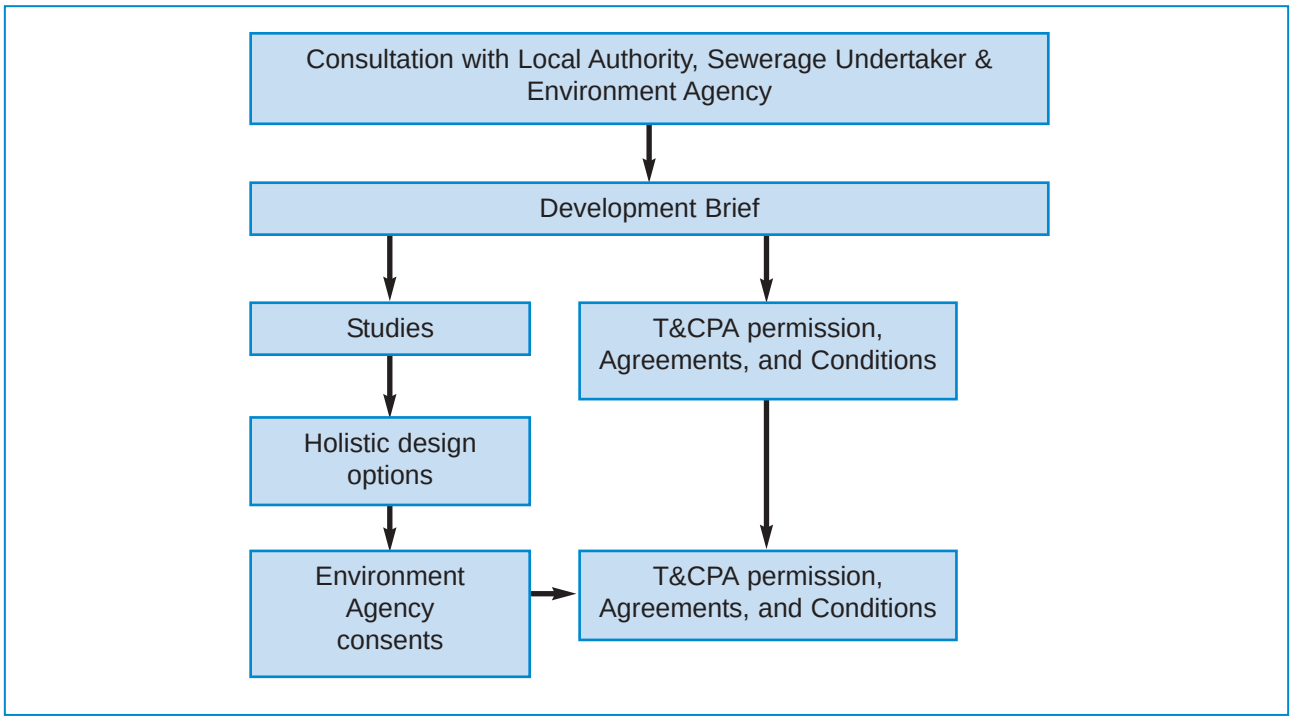

Figure 2.2 *The T&CPA process*

2.2 Stages of phased management of the development

Design is generally an iterative process that starts from an initial concept and is gradually refined to produce an optimum solution. The final solution should provide best value for money against the project objectives within political, economic, environmental, social and technical constraints.

To manage the design process effectively, the design should progress though a series of steps, with increasing levels of detail as it moves forward. At the end of each step, the solution should be evaluated against the project objectives and formally agreed with the client before proceeding to the next step.

The process is shown in Figure 2.3, which should be modified to suit the requirements of individual clients and projects.

It should be noted that the degree of cost certainty increases as the project progresses, ranging from only about ± 30 per cent cost certainty at the end of feasibility to about ± 5 per cent at the end of detailed design.

RIBA Stage	Brief description	Main Actions	Key outputs
1	**Feasibility**	• confirm development brief • make initial contact with EA/SEPA, Sewerage Undertaker, Local Authority, other services Highway Authority • Obtain ground conditions • Identify site constraints • Investigate disposal options • Identify flood paths • CDM risk analysis	• Preferred point of foul disposal • Preferred means of surface water disposal • Abnormal features/costs • Requirements for additional surveys • Flood potential • Identify principle H&S hazards
2	**Outline design** Need for sub soil drainage Any drainage diversion Established design parameters CDM risk analysis Key levels	• Layout of principal foul and surface water drains in plan • Layout of principal foul and surface water drains in long section • Estimate discharge rates • Calculate sizes of drainage features (eg pipes, separators, balancing) using approximate methods • Method of paved drainage (ie gullies, linear drains etc)	• Agreement in principle of adoption • All principal elements, eg separators, pipework layout, balancing, for costing • Input into H&S plan
3	**Detailed design**	• Confirm all foul connection points • Confirm all surface water connections • Access arrangements (ie manholes, inspection chambers) positions, levels and sizes • Select pipe materials and calculate strengths and bedding • CDM risk analysis • Check for pipe clashes	• Position level and size of all pipework & chambers • Drawings and specifications for tendering and legal arrangements • Input into H&S plan
4	**Production information**	• Prepare details of structures • Prepare maintenance guidance	• Sufficient information for construction and maintenance • Input into H&S file

Figure 2.3 *Design process*

2.3 The T&CPA procedure

Obtaining T&CPA approval and discharge consent for site development drainage can cause considerable frustration. The process is quite complicated, partly due to the number of regulators and authorities that are involved. This section provides guidance on the approach needed to obtain consent requirements by the organisations involved, and the procedures and requirements of the T&CPA process.

The developer has to go through a process of submitting site development proposals to the local authority to get approval to implement them. This procedure has several stages between the initial application and the start of construction, which is illustrated in Figure 2.2.

Preliminary pre-application consultation is often beneficial and avoids unexpected problems and delays at the T&CPA application stage. Time should be allowed for option reviews and collection of data.

Although the local authority is responsible for this process, it normally involves other organisations such as the Environment Agency or the sewerage undertaker in obtaining approval for drainage proposals.

The principal regulatory authorities involved are summarised in Table 2.1.

Table 2.1 *Principal regulators and their responsibilities*

COUNTRY	REGULATOR/AUTHORITY	RESPONSIBILITY
England and Wales	Environment Agency	Groundwater and controlled waters
		Main river consents
		Non-main river advice/consents
	Internal drainage board	Non-main river consents
	Local authority	T&CPA approval
		Non-main river consents*
		Building regulations**
		Highway drainage
	Sewerage undertaker	Sewer consents
		Adoption of sewers
	BWB, NT etc	Discharge consents
Scotland	Water authority	Sewer consents
	Regional and city councils	Flood defence
		River discharge consents
	SEPA	River discharge consents (water quality)
		Groundwater consents
Northern Ireland	DoE (NI)	Sewer consents
		Groundwater consents
		River discharge consents

* The local authority generally receives advice from the Environment Agency (statutory consultee) before issuing consents for non-main rivers

** Or other approved building control organisation.

Figure 2.4 provides a simple overview of the responsibilities of organisations in the UK that might be involved in dealing with drainage aspects of a development.

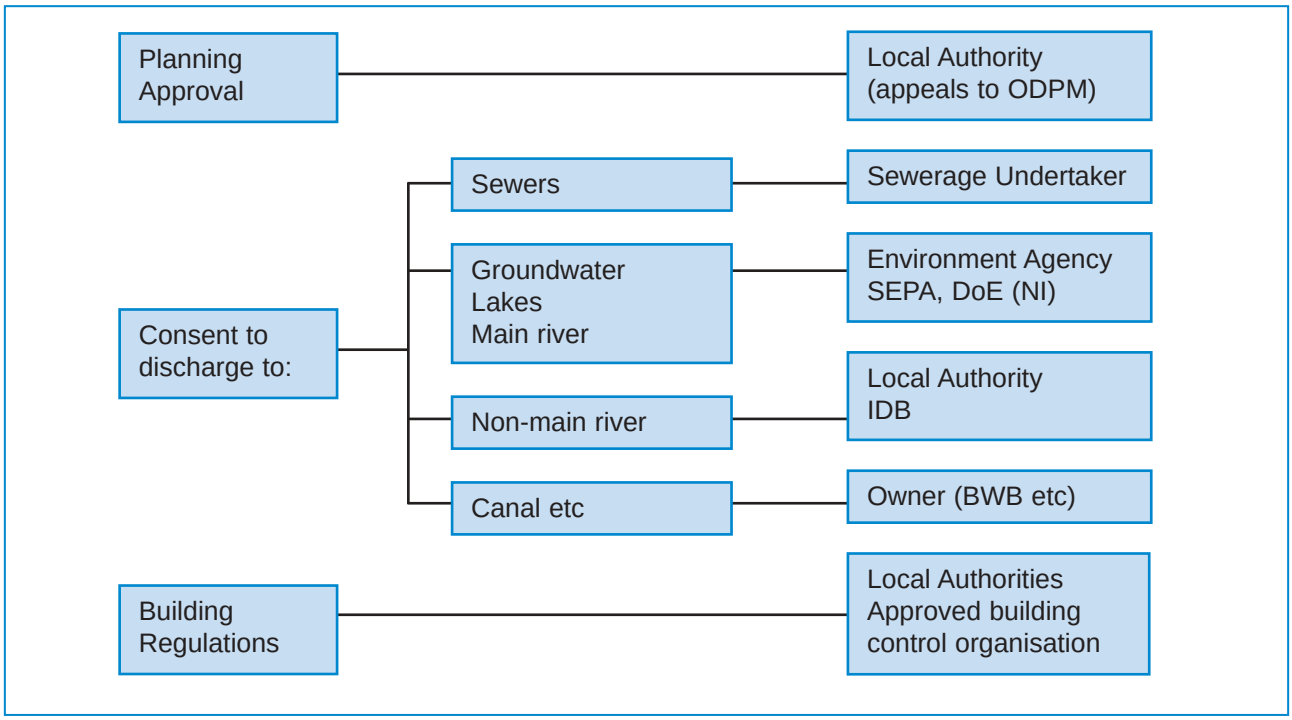

Figure 2.4 *Responsibilities for T&CPA, discharge consents and building regulations*

A more detailed description covering the interaction of all the possible bodies involved is given in CIRIA Report 124 (Maskell *et al*, 1992).

The T&CPA application form asks the question: "How will surface water drainage be disposed of?". The options, or combination of options, available to answer these questions are:

- soakaway or other on-site infiltration
- public sewer
- highway drains
- non-main river
- main river.

After any pre-application consultation, the process for considering drainage proposals is as follows.

1. A T&CPA liaison officer in the local authority reviews the application to assess whether the drainage proposals require a formal meeting between the authority, the Environment Agency, the sewerage undertaker or any other body.
2. The local authority (usually in conjunction with the Environment Agency) considers:

- the risk of flooding on the site (Environment Agency floodplain policy)
- environmental aspects of the site (including habitat protection)
- opportunities for sustainable drainage techniques
- geological characteristics of the site
- the need for on-site attenuation (of surface water runoff)
- the limitations of off-site drainage capacity.

3. The drainage officer within the local authority advises on T&CPA consultation with the Environment Agency (a statutory consultee under the Town & Country Planning Order 1995) based on the categories listed in Liaison with local planning authorities (Environment Agency, 1997a). The Environment Agency may advise the developer to review the requirements for the site.
4. The sewerage undertaker is consulted on larger developments where public sewerage systems are to be connected. Both sewerage capacity and sewage treatment are considered. Water supply is also assessed, but lack of capacity does not necessarily lead to a refusal of T&CPA approval.
5. Legal agreements may be needed between the developer and the T&CPA authority.

2.4 Categories of drainage design

This section provides a summary of the drainage design activities and the authorities that are involved. Each of these aspects is considered in more depth in Chapters 4 to 10 of this guide.

Table 2.2 summarises the various aspects of site drainage, the authority involved in the approval process and the key documents that define criteria and the requirements or standards that need to be met. Some criteria are location-specific, so they are not provided in the reference documents. In these situations, discussion with the authority responsible is needed to determine the requirements. This is particularly true for control and storage of runoff.

The table refers to authorities in England and Wales. The equivalent organisation (as detailed in Section 2.3) should be referred to in Scotland or Northern Ireland. Appendix A provides more detailed information on the authorities and their roles.

Table 2.2 *Design responsibilities and key documents in UK*

Drainage issue	Responsible authority	Key reference documents
Runoff rate to watercourse (post-development)	Environment Agency/local authority	The Wallingford Procedure (HR Wallingford and IH, 1981a)
Surface runoff into drainage system (post-development)	Sewerage undertaker	Sewers for adoption (WRc, 2001)CIRIA Report 124 (Maskell *et al*, 1992)
Design of sewers	Sewerage undertaker	Sewers for adoption (WRc, 2001)
Protection of groundwater	Environment Agency/SEPA	Policy and practice for the protection of groundwater (EA, 1998a)
Building Regulations	Local authority	Building Regulations (England & Wales) Part H, edition 2002
Roof drainage	Local authority	BS EN 12056-3:2000
Road drainage Car park drainage	Local authority	BS EN 752:1997 BS EN 1433:2002 HA 37/97 (Highways Agency, 1997)
Flood risk	Environment Agency	PPG25 (DTLR, 2001)
Soakaways	Environment Agency/Local authority	CIRIA Report 156 (Bettess, 1996) BRE 365 (BRE, 1991)
Floodplain development	Environment Agency	PPG25 (DTLR, 2001)
Runoff from greenfield sites	Environment Agency/Local authority	FSSR 16 (IH, 1985) MAFF Report 345 (MAFF, 1981) Report 124 (IH, 1994) HR Report SR 591 (Kellagher, 2002b)
Sustainable drainage systems	Environment Agency/SEPA/Local authority	CIRIA C521 (Martin *et al*, 2001a) CIRIA C522 (Martin *et al*, 2001b) CIRIA C523 (Martin *et al*, 2002)

Section 2.6 provides details of all these key reference documents.

2.5 Building Regulations

Different legislation applies to building works in England and Wales, Scotland and Northern Ireland, as shown in Table 2.3.

Table 2.3 *Building Regulations legislation in UK*

	England and Wales	Scotland	Northern Ireland
Building Regulations	The Building Regulations 2000	Building Standards (Scotland) Regulations 2001 – amendment to 1990 Regulations	Building Regulations (Northern Ireland) Order 1997 – amendment to 1994 Regulations

Drainage works are normally covered by Building Regulations (although there are exceptions such as agricultural activities). These Regulations are written to meet the requirements of the Building Act 1989. The Building Regulations in England and Wales require drainage to "be adequate". Guidance on what is considered to be adequate is given in Approved Document H to the Building Regulations, edition 2002, which, as well as giving advice for domestic dwellings, also refers to the British Standards on the subject. For works in and around buildings, Building Regulations approval is needed. The "alternative approach" to satisfying the requirement for drainage to be adequate is to comply with recognised standards.

The Building Regulations also cover sanitary conveniences and washing facilities. The main matter relating to measures for the prevention of sewer flooding is the requirement in Approved Document G1 to the English and Welsh Building Regulations, which stipulates that householders must have access to a WC connected directly to a gravity drainage system.

The latest revision of Building Regulations Part H (edition 2002) aims to bring about a convergence in the standards of the construction of private and public sewers.

Building regulation control is exercised by local authorities and also by approved independent firms in certain instances.