

A Public Guide to Managing Stormwater Drainage on Residential Properties



Catchments
& Creeks

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A Public Guide to Managing Stormwater Drainage on Residential Properties

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Disclaimer

Significant effort has been taken to ensure that this publication is sufficiently generic in its content for it to be used as a general, non-technical, public reference document. However, the generic nature of the document means that this publication is unlikely to address all of the stormwater issues relevant to a particular property, or to provide sufficient information to allow the reader to design the stormwater drainage system for a particular residential property.

Managing stormwater drainage on residential properties can in some case be very complex, and the solutions often require the guidance of experienced experts. Users of this document should never underestimate the benefits of seeking expert advice, especially if a property is located at the bottom of a valley, or adjacent to a waterway.

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It is strongly recommended that readers seek their own site-specific advice from trained professionals before purchasing or renting a residential property.

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Purpose of document

This publication does **not** represent a comprehensive engineering or technical guideline to the design of stormwater drainage systems. Stormwater issues are only discussed from a generic, non-technical perspective. The publication focuses only on Australian practices, but does not align with any particular state or territory's drainage standards.

The purpose of the document is to:

- provide generic, non-technical information on stormwater drainage issues associated with residential properties and dwellings
- assist the public in understanding many of the drainage issues associated with design and operation of residential properties and dwellings
- increase the public's awareness of those stormwater issues that could influence their decision to rent or purchase a property, and as a result, increase the likelihood of a person seeking appropriate expert advice before making such a decision
- increase the public's awareness of the common law principles that are often applied to the resolution of neighbourhood conflicts relating to stormwater drainage; however, this document is **not** a substitute for residents seeking their own professional legal advice.

This document does not provide information on building and drainage design codes.

The photos presented within this publication are intended to be representative of the topic being discussed. These photos usually depict either a 'preferred' or an 'undesirable' outcome (as the case may be). In some cases the selected photos may not represent the best possible outcome or situation, but may simply be the best photo available to the author at the time of publication.

It should not be implied from the photo caption or associated discussion that the property shown within the photograph is representative of either good or bad stormwater practice. **In some cases the photos have been digitally altered to better represent the topic being discussed, and as such may no longer be representative of the actual site conditions.**

About the author

Grant Witheridge is a civil engineer with both Bachelor and Masters degrees from the University of NSW (UNSW). He has over 35 years experience in the fields of hydraulics, stormwater management, creek engineering and erosion & sediment control, during which time he has worked for a variety of federal, state and local governments, and private organisations.

Grant commenced his career at the UNSW Water Research Laboratory constructing and operating physical flood models of river floodplains. He later worked for Brisbane City Council on creek engineering and stormwater management issues. He currently works through his own company Catchments & Creeks Pty Ltd. He is the principal editor of the 2007, 2013 & 2016 editions of the Queensland Urban Drainage Manual, as well as numerous other publications.

Introduction

It is important not to confuse 'property drainage' with 'property flooding'. *Property flooding* can result from the direct intrusion of rainwater into a building, the overland passage of stormwater flows, or the effects of creek or river flooding. *Property drainage* is the process of managing the passage of stormwater and groundwater flows through a property. It is a different process to that of flood proofing of properties, and usually requires different professional expertise.

Drainage problems are usually very different from flooding problems. Drainage problems are more likely to be associated with:

- building activities that interfere with groundwater flows
- damaged roofs
- damaged or poorly-designed roof water drainage systems
- overland stormwater flows passing through a property, or
- structures, such as fences, interfering with the flow of stormwater run-off.

Unlike flooding issues, most drainage problems can be solved through appropriate drainage design. However, even though appropriate drainage practices can prevent some forms of property flooding, not even the best drainage system can prevent the types of property flooding experienced as a result of creek or river flooding.

Introduction



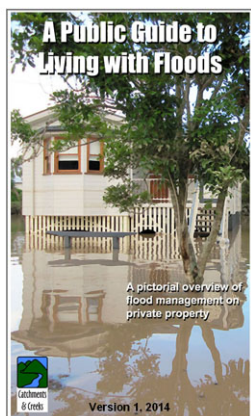
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Roof-water drainage

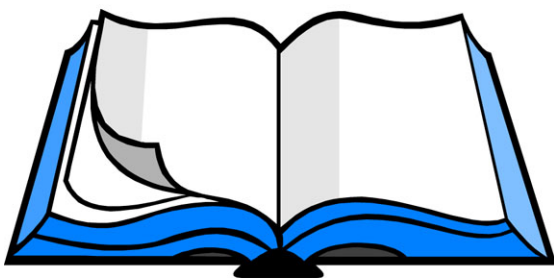


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Installation of roof-water drainage system



A Public Guide to Living with Floods



Structure of this document

What is 'stormwater'

- The term 'stormwater' is used to describe that part of rainfall that directly runs off the land surface.
- Stormwater run-off may either travel down the drainage catchment as 'surface flow' or within conduits as 'piped flow'.
- The term 'stormwater' also includes any contaminants (pollutants) collected by the water during its travels.
- Stormwater does not include that part of rainfall that soaks deep into the soil or evaporates from the land surface.

What is 'drainage'

- Drainage, specifically stormwater drainage, is the natural or artificial means of intercepting and transporting stormwater run-off.
- Stormwater drainage includes:
 - perforated subsoil drainage pipes that collect groundwater from the soil
 - impervious sub-surface pipes that transport stormwater underground
 - open surface drains that transport stormwater over the land surface.

Related publication

- The reader's attention is drawn to the related C&C publication (left) that addresses those issues relating to property flooding.
- Even though drainage problems can cause property flooding, most property flooding results from floodwaters passing along creeks and rivers.
- Flooding problems usually require advice and solutions that are different to those applied to the management of stormwater drainage.

Structure of this publication

This document seeks to address residential drainage issues associated with the following circumstances:

- **Part 1:** Things to consider before buying or renting a home
- **Part 2:** Things to consider when designing or modifying a home
- **Part 3:** Managing stormwater drainage on an existing property
- **Part 5:** The rights and obligations of landowners and occupiers

Document content



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Property sale

Part 1: Things to consider before buying or renting a home

- This chapter provides general information and guidance on those stormwater issues that are likely to influence a person's decision to rent or purchase a property.
- Guidance is provided on how different building types and building locations can influence their interaction with stormwater flows.
- Guidance is also provided on the different types of pre-sale property inspections.



Photo supplied by Catchments & Creeks Pty Ltd

Building construction

Part 2: Things to consider when designing or modifying a home

- This chapter provides general guidance on those issues that should be considered when designing or modifying a home.
- A warning is given on the importance of good drainage design when designing a low-set (slab-on-ground) home.
- General advice is provided on drainage design; however, readers should also refer to Part 3 of this document for more discussion on the design of drainage systems.



Photo supplied by Russell Cuere

Overland flow during a major storm

Part 3: Managing stormwater drainage on your property

- This chapter provides general information on the management of stormwater drainage on residential properties.
- Advice is provided on managing stormwater flows entering your property, stormwater flows passing through your property, and stormwater flows leaving your property.
- Information is also provided on managing stormwater quality and safety issues.

Part 4 provides a brief overview of council drainage systems.

Part 5: Rights and obligations of landowners and occupiers

- This chapter provides **general** information on legal issues relating to stormwater management and the resolution of neighbourhood disputes.
- This chapter does **not** constitute professional legal advice.
- Readers are advised to always seek their own site-specific legal advice if disputes cannot be resolved through direct discussions between all parties.



Photo supplied by Catchments & Creeks Pty Ltd

Application of the law

Understanding who is responsible for managing stormwater



Property inspection



Photo supplied by Catchments & Creeks Pty Ltd

Drainage through a property



Photo supplied by Catchments & Creeks Pty Ltd

Local council



Photo supplied by Catchments & Creeks Pty Ltd

Residential property

Collecting information

- Prior to purchasing a home, why not take the time to arrange investigations into potential flooding and drainage problems.
- If these initial inspections identify any concerns, then arrange for an expert to carry out a more detailed investigation and to provide cost estimates for any repairs.
- Your plumber can provide advice on roof drainage; however, a drainage engineer may be required to investigate wider property drainage issues, including flooding.

Solving drainage problems

People are often confused about the role councils are required to play in regards to investigating and solving drainage problems.

- If the issue is solely on your property, then it is usually your problem to solve.
- If the issue involves neighbouring properties, then in most cases it is not a council issue, unless one of the properties is undergoing formal development.
- If the issue involves council controlled land or a council-approved development, then it is a council issue.

Council's responsibilities

- It is usually not the responsibility of the local government to investigate drainage problems on your property.
- Council's role is normally limited to:
 - checking that buildings and their drainage comply with the relevant building codes—a task that may also be performed by a private certifier
 - managing drainage on public land
 - providing advice on creek and river flooding where such information is known to the council.

Landowner's responsibilities

- Property owners generally have the following responsibilities with regards to stormwater management on their land:
 - seek-out flood risk information from their local or state government
 - ensure that the property's stormwater drainage system complies with local building/plumbing codes
 - resolve any drainage problems left unresolved by the previous landowner
 - resolve any drainage problems totally contained within their own property.

Part 1: Things to consider before buying or renting a home

Natural disasters



Landslide and mudslides



Wind damage



Fire damage



Flood and storm damage

Earth

- The purchase of a home is a time for clear rational thinking—it is a time to ask questions and get answers.
- Firstly, can you afford the home, and secondly, can you afford the consequences of something going wrong, such as a natural disaster?
- Natural disasters can include landslides, winds, fire and floods.
- Landslides and mudslides can result from numerous problems including subsoil drainage problems.

Wind

- The adoption of modern building codes is the best way to prepare your home for possible windstorms.
- When buying a home, especially homes that are over ten years old, it is important to commission a professional building inspection to report on the building's compliance with current building codes.
- If the roof has been replaced with corrugated metal sheeting, then check that the roof is appropriately tied to the building foundations (not just the building frame).

Fire

- Bushland settings are often associated with an elevated fire risk.
- Different types of bushland (e.g. rainforest, dry sclerophyll) experience different levels of fire risk.
- Your local fire authority and/or council should be able to provide advice on the fire risks associated with your property.

Water

- The water threat can come from many sources, including rainfall, stormwater, floods, storm surge and coastal waves.
- Most drainage problems can be solved by appropriate building repairs and/or modifying the property's landscaping.
- Property flooding however, may not be so easily to resolve—so buyer beware.
- This publication aims to provide home owners and residents with assistance in addressing only drainage problems, not creek or river flooding.

Pre-purchase property inspections



Photo supplied by Catchments & Creeks Pty Ltd

New residential subdivision

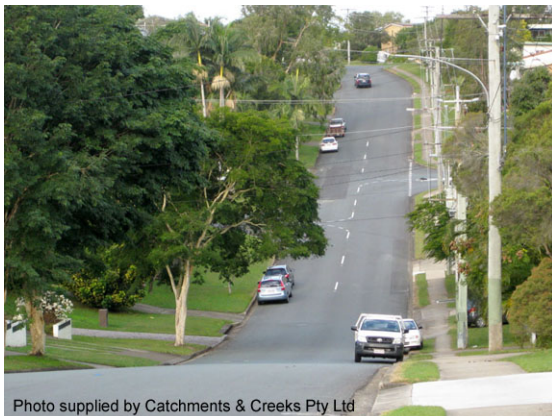


Photo supplied by Catchments & Creeks Pty Ltd

Hills and valleys of an urban landscape



Photo supplied by Catchments & Creeks Pty Ltd

High-set 'pole' home



Photo supplied by Catchments & Creeks Pty Ltd

Low-set 'slap-on-ground' home

Responsibilities of the purchaser

- When purchasing a property, it is **your** responsibility to organise the necessary building inspections and to obtain the necessary flood and drainage reports.
- It is **not** the council's job to approach you with information about any drainage problems associated with your property.
- Do **not** rely on the advice of the existing owner, a real estate agent, or the neighbours—their advice may ultimately be correct, but a wise buyer always seeks independent expert advice.

Location, location, location

- The location of a property has a strong bearing on the types of drainage and flooding problems that may exist.
- The **first** thing to note is the position of the property in relation to the hills and valleys of the local topography.
- Remember; valleys form the primary flow path for concentrated stormwater run-off.
- Do **NOT** assume that a council-approved drainage system will prevent stormwater flowing **over** the ground during severe storms.

Position of the house on the property

- Owning land that is flood prone is very different from owning a 'home' that is flood prone.
- Stormwater run-off occurs over the surface of **all** properties during severe storms; so the key to a flood-free home is the elevation of floor levels relative to (i) expected flood levels **and** (ii) the surround land levels.
- Homes **must** also be positioned to allow excess stormwater run-off to flow safely around or under the building.

Elevation of the floors relative to the surrounding ground level

- Some homes are constructed on concrete slabs that cut into the slope of the land.
- This construction method often places the floor level below the natural ground level on at least one side of the building.
- In such cases it is important that the land is contoured to direct stormwater run-off around the building.
- **Never** assume an underground drainage system will take all stormwater around a building.

Types of buildings



Low-set home

Low-set homes

- Currently the most common form of building construction is 'slab-on-ground'.
- Warning; just because the home is modern, and complies with current building codes, does not mean that it will not experience drainage problems.
- This type of construction is generally not recommended for homes located on flood-plains or along the invert (floor) of valleys.
- 98% of these homes will not experience drainage problems; avoid the 2% that do.



Home built on stumps

Homes on stumps

- Placing a home on stumps or brick footings can significantly reduce the risk of flooding and drainage problems.
- However, it is still important to ensure (through a council flood search) that the floor levels are well above expected flood levels—not 'just' above, but well above.
- Also, ensure that air is able to circulate freely under elevated building to allow the ground to dry out after heavy rainfall.



High-set home

High-set homes

- Elevated pole homes are generally the best option for flood-prone areas.
- However, drainage and flooding problems can still arise if the lower level is enclosed (post building approval) to make 'better' use of the space.
- Check if building modifications have been made to the home to add:
 - additional bedrooms
 - ground floor rental accommodation
 - playrooms or storerooms.



Inter-allotment retaining walls

Floor pads cut into the hillside

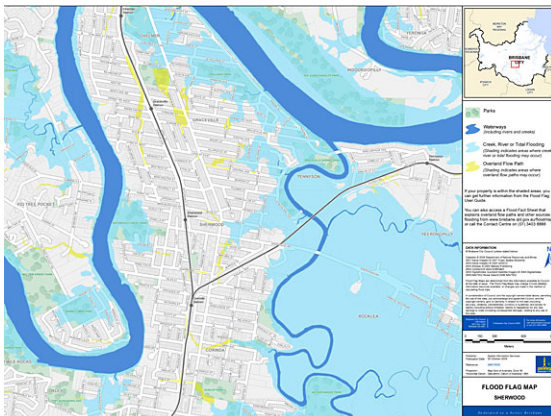
- Modern building practices often require the formation of a level building platform partially surrounded by retaining walls.
- Issues to consider when buying a property that contains retaining walls include:
 - how long are the walls expected to last before the building materials begin to fail and the walls need to be replaced
 - is groundwater seepage through the retaining walls likely to become a problem—such problems are often only evident after prolonged rainfall.

Property investigations

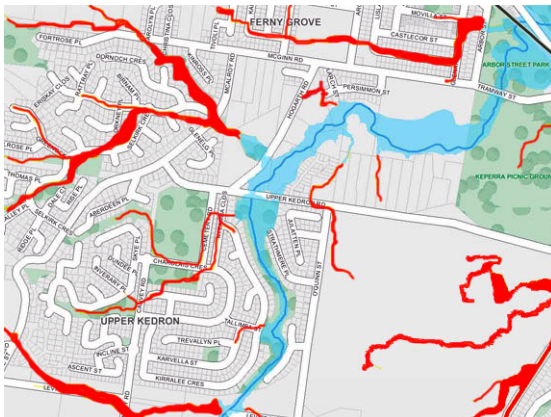


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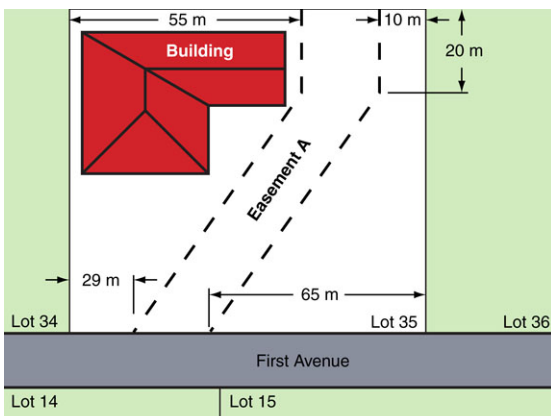
Property sale



Flood map (Brisbane City Council)



Overland flow (red) and creek flooding



Drainage easement plan

Investigating potential problems

- The purchase of a home is likely to be one of the biggest investments you will ever make—so why not take the time to investigate the risks of drainage or flooding problems.
- A building/plumbing inspector can determine if the building complies with relevant building and plumbing codes.
- A consulting engineer specialising in flooding and drainage can interpret government-supplied flood data and/or carry out site-specific flood modelling.

Flood maps

- Governments often provide flood maps to help people identify flood-prone areas.
- Flood maps usually identify only those properties directly affected by creek or river flooding.
- But note; local drainage problems can also cause stormwater flooding well outside these mapped (blue) areas.
- If such drainage problems occur solely on private property, then it may not be the responsibility of the council to investigate, map, or resolve such issues.


Overland flow paths

- Some flood maps not only identify areas subject to creek and river flooding, but also the location of major overland flow paths (here shown in red, but may appear in another colour on other maps).
- These maps identify only those areas subjected to 'concentrated' overland flow.
- Overland flows generally only cause property flooding when a blockage occurs along the flow path (such as a solid fence), or a property has a poorly designed drainage system.

Registered drainage easements

- The existence of a drainage easement does not necessarily mean that the property has a drainage problem, but it does suggest that further investigations should occur before purchasing the property.
- Drainage easements may exist on a property for a number of reasons, including:
 - protection of underground pipes
 - protection of an overland flow path
 - protection of an open stormwater drain.

Building and property inspections

BUILDING
**INSPECTION**
REPORT

CLIENT: ADDRESS:

PHONE: FAX:

PROPERTY INSPECTION AT: WOOD INFESTATION INSPECTION:

Building inspection report



Flood map for Oxley

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ENGINEERS—See		ENGINEERS (Cont'd)	
Aeronautical Engineers.....	88	Power Transmission Equipment & Supplies.....	L-Z 1686
Bio-Medical Engineers.....	227	Precision Engineers.....	L-Z 1687
Chemical Engineers.....	413	Printing Engineers.....	L-Z 1696
Civil Engineers.....	441	Radio Distributors, Parts & Service.....	L-Z 1716
Combustion Engineers.....	474	Refrigeration Engineers.....	L-Z 1745
Designing Engineers.....	641	Repetition Engineers.....	L-Z 1753
Diesel Engineers.....	642	Sound Engineers.....	L-Z 2012
Electrical Engineers.....	775	Steam Engineers.....	L-Z 2029
Electronic Engineers.....	779	Structural Engineers.....	L-Z 2061
Engineers-Consulting.....	794	ENGINEERS-AUTOMATION—See	
Engineers-General.....	797	Automation Systems & Equipment.....	168
Engineers-Installation &/or Maintenance.....	799	ENGINEERS-COMMUNICATION—See	
Engineers-Manufacturing.....	799	Radio Communication Equipment & Service.....	L-Z 1714
Geotechnical Engineers & Consultants.....	996	Telephone Systems & Equipment.....	L-Z 2123
Heating, Hot Water & Ventilating Engineers.....	1060	ENGINEERS-CONSULTING	794
Hydraulic Equipment & Supplies.....	1124	See Also	
Marine Engineers.....	L-Z 1355	Geotechnical Engineers & Consultants.....	996
Mechanical Engineers.....	L-Z 1370	ENGINEERS-GENERAL	797
Mining Engineers.....	L-Z 1379		
Motor Engineers & Repairers.....	L-Z 1411		
Plastics-Toolmakers & Engineers.....	L-Z 1630		

Continued Next Column

'Yellow Pages' listing



Photo supplied by Catchments & Creeks Pty Ltd

Gully erosion up-slope of new home

Property inspections

- Various professional property inspections should be arranged prior to the purchase of a property.
- These reports include:
 - a building inspection by a qualified building inspector
 - a search for any easements that may exist across the property
 - a flood search.

Flood search

- In most cases a flood search conducted through the local council will provide all the necessary flood information in regards to potential creek and river flooding.
- However, this type of flood search will not necessarily provide all the information you need; for example, it may not include information on the flood risks associated with overland flows (i.e. stormwater).
- In some cases, additional property inspections will be required, which will involve searching for the right consultant.

Consulting engineers

- Civil engineering is the branch of engineering that normally deals with flood and drainage investigations.
- However, an Internet/Yellow Pages search for a civil engineer is likely to list mainly those engineers that focus on structural design and/or civil construction.
- Engineers that specialise in stormwater management and flood investigations are more likely to be listed under the heading '*Engineers – Consulting*'.

Soil investigations

- If your building proposal involves cutting into the side of a steep slope to form building foundations, then a geotechnical investigation is recommended.
- If the soil tests identify dispersive, sodic or slaking soils, then advice from a 'soil scientist' may be required.
- If the soils are chemically unstable, then cutting into the hill-slope may have the potential to initiate major gully erosion problems, or worse, landslips.

Building and property inspections



Roof drainage

Roof drainage

- Reports on the drainage systems of existing buildings are usually included in the 'building inspection' conducted by a registered building inspector.
- A plumber can be engaged to further investigate specific issues identified within the initial building inspection.
- Specialist roofing contractors can also identify and rectify roof drainage problems.



Property drainage

Property drainage

- Investigations into potential overland flow problems (including the management of stormwater run-off entering your property from adjacent properties), normally requires a drainage engineer.
- The drainage engineer may also be able to recommend if you need to seek legal advice to resolve certain matters.
- If the drainage problems are not major, then your plumber may be able to advise you on a suitable drainage solution.



Failed rock retaining wall

Retaining walls

- Retaining walls can present many potential problems to a home-owner.
- Most of the problems associated with retaining walls relate to either subsoil drainage or land instability issues.
- Drainage issues should be investigated by a stormwater or geotechnical consultant.
- Land stability issues should only be investigated by a qualified geotechnical consultant (your landscape consultant may not have the required training).



Creek bank failure

Creek and riverbank erosion

- If a home is located on a steep slope, or close to the banks of a watercourse, then landslips or bank erosion could threaten to undermine the building.
- Always ask yourself: why is the home up for sale?
- A civil engineer or river morphologist will be required to investigate the risk of watercourse erosion.
- A geotechnical engineer may be required to investigate the potential for a future landslide.

Understanding the different types of storms



Thunder storm



Photo supplied by Catchments & Creeks Pty Ltd

Stormwater inlet for minor storm flows



Photo supplied by Catchments & Creeks Pty Ltd

Overland flow during a major storm



Severe storm flows in Toowoomba, 2011

Stormwater terminology

- Before discussing the key stormwater issues that may affect your decision to buy a home, it is important for this document to provide an overview of some of the terms commonly used within the stormwater industry.
- Unfortunately the terminology used in the stormwater industry does vary from region to region; however, the following terms have reasonably common usage.

Minor storms

- 'Minor storms' are those frequent storms that occur more often than once in ten years—the type of storm where an umbrella will actually keep you dry.
- Stormwater run-off from minor storms can usually be captured and conveyed by underground (piped) drainage systems, or shallow grassed drains (swales).
- The design of the minor drainage system on a residential property is normally done by a plumber or the building designer.

Major storms

- 'Major storms' are those less frequent storms that only have a 1% to 10% probability of occurring each year—during these storms it can be difficult to see through the windscreen of a car, and it is unlikely that an umbrella will keep you dry.
- Rarely can underground drainage systems cater for the increased run-off generated by these storms; instead, the drainage system will likely surcharge causing overland flows to occur through residential properties.

Severe storms

- The term 'severe storms' can sometimes include the category of 'major storms', but increasingly this term is being used to describe the very rare storms that have an intensity that exceeds the maximum 'design storm' of the council's drainage system.
- Typically these storms have a probability of less than 1% of occurring in any year, which means they have a likelihood of less than once in 100 years.
- These are real storms, that can, and have already occurred around the country.

Stormwater issues



Typical stormwater flows within a valley



'Sag' type kerb inlet



'On-grade' kerb inlet



Residential stormwater (field) inlet

Homes built along the valley floor

- The risk of flooding from overland flows is increased when homes are constructed along the floor of natural valleys.
- Before investing in such properties it is important to confirm that appropriate measures have been taken to manage overland flows through the property.
- Controlling overland flows by attempting to 'pipe' all stormwater run-off under a building is not a recommended strategy—there can always be a bigger storm that will eventually cause surface flows.

Roadside stormwater inlets

- There are two types of roadside stormwater inlets, 'sag inlets' and 'on-grade inlets'; however, their appearance can vary around Australia.
- Sag inlets typically have a metal grate located in the middle of the kerb opening.
- These inlets normally exist at the lowest points in a road profile such as a valley.
- A sag inlet located outside a property may indicate that overland flows are possible through the property during major storms.

On-grade kerb inlets

- On-grade inlets normally have the metal grate located at the down-slope end of the kerb opening (but not always).
- On-grade inlets can exist at almost any location along a roadway, except at road depressions and the valley floor (sags).
- The existence of an on-grade kerb inlet outside a property does **not** indicate that any specific drainage problems are likely to exist on that property.
- Older kerb inlets may look significantly different from these modern examples.

Stormwater inlets located within a property

- A 'field inlet' is a stormwater inlet located within open ground.
- Field inlets are often located along overland flow paths, and at depressions within a property where stormwater run-off will likely collect.
- Local flooding problems can occur if these inlets become blocked with debris.
- It is important to consider what will happen if any stormwater inlet becomes fully blocked with debris—such as litter or garden mulch.

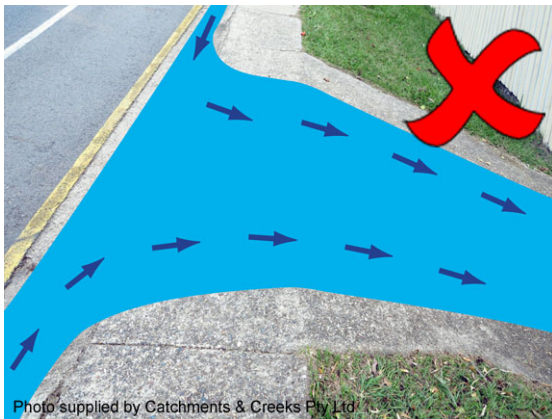
Stormwater issues



Roof-water drainage system



Stormwater flow down a gravel path



Driveway lowered which allows inflow



Installing a new property fence

Roof drainage

- The protection of homes from storms begins with good roof drainage.
- Look for water stains on the ceilings.
- Warning; roof insulation can delay the signs of a leaking roof—therefore consider asking for a detailed roof inspection.
- Look for signs of erosion directly below the gutters that may indicate gutter blockages or poor gutter maintenance.
- Wide (175 mm) roof gutters can make the annual cleaning of gutters much easier.

Overland flows

- Many residential properties experience infrequent occurrences of 'overland flow'.
- Walk around the property and consider any locations where stormwater run-off could enter the property from up-slope properties, including a roadway.
- Then look down-slope through the property and confirm that stormwater run-off has an unobstructed flow path.
- Problems usually occur when people try to interfere or change the 'natural' travel path of overland flows.

Road run-off

- If the property is located below the elevation of an adjoining roadway, then the property may be subject to stormwater run-off spilling into the property from the roadway.
- Check that the driveway entrance has not been lowered below the adjacent footpath—this may increase the risk of stormwater inflows into the property.
- If the property sits in a valley, then it may not be possible to prevent road run-off entering the property.

Property fencing

- It is important to study the property fencing and consider its impact on overland flows.
- Historically, property fencing typically consisted of an open style that allowed the free passage of stormwater run-off.
- Renovated properties often install solid fencing (e.g. to enclose a swimming pool) such fencing can interfere with the natural passage of overland flows causing property flooding and potentially some unresolved disputes with neighbouring properties—so ask questions!

Flood related stormwater issues



Photo supplied by Catchments & Creeks Pty Ltd

Raised fencing over an overland flow path

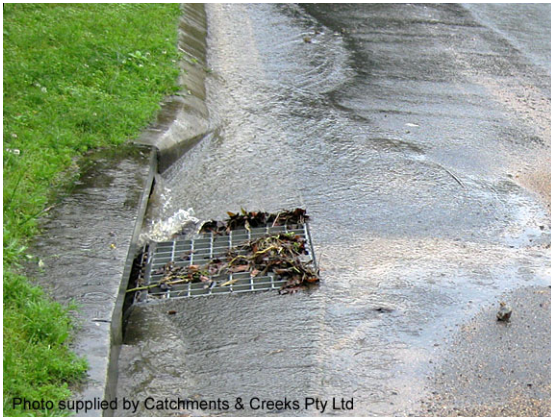


Photo supplied by Catchments & Creeks Pty Ltd

Roadside kerb inlet to a stormwater pipe



Photo supplied by Catchments & Creeks Pty Ltd

Backup of tidal water into coastal suburb



Photo supplied by Catchments & Creeks Pty Ltd

Rubber 'duckbill' backflow control

Stormwater flooding

- The risks of stormwater flooding are best minimised by ensuring:
 - floor levels are set above the expected overland flow water level—this may require analysis by a drainage engineer
 - suitable overland flow paths exists in the event that blockages occur within the piped drainage system
 - any new landscaping or fencing placed around a home does not block these essential overland flow paths.

Solving stormwater related flood issues

- Councils often receive requests from residents to increase the capacity of the drainage system installed on their local roadway.
- In some case, increasing the capacity of a drainage system can solve local flooding problems.
- However, in many other cases the solution to the flooding problems cannot be found simply through an increase in the council's drainage system.

Limited benefit of drainage pipes

- If the property flooding is the result of 'backwater' flooding from an adjacent creek or river, then increasing the pipe capacity will not reduce the risk of such flooding.
- In some rare cases, an increase in the size of stormwater pipes can actually increase the risk and/or severity of backwater flooding from an adjacent waterway.

Use of backflow control devices

- To limit the adverse effects of backwater flooding along drainage pipes, some stormwater pipes are fitted with backflow control valves.
- Backflow control devices can be very useful in low-lying suburbs, especially land protected by flood levees.
- However, there are many complications associated with these systems and not all councils and stormwater engineers recommend their use.

Part 2: Things to consider when designing or modifying a home

Design considerations



Photo supplied by Catchments & Creeks Pty Ltd

New building works



Photo supplied by Catchments & Creeks Pty Ltd

Site meeting



Home located on highest ground



Photo supplied by Catchments & Creeks Pty Ltd

A choice of building style

Introduction

- The key to a successful drainage design is the appropriate consideration of:
 - the building style
 - minimum floor level
 - garage and driveway design
 - roof water drainage
 - land filling and earth retaining walls
 - subsoil drainage
 - minor storm drainage
 - major storm drainage
 - property landscaping and fencing.

Responsibilities of the property owner

- When building a home, it is ultimately your responsibility to ensure that appropriate people are involved in its design—this may involve several different experts.
- The best advice is for home owners not to rely solely on the advice of their builder, but to seek out expert advice from specialists in the industry if there is the risk of drainage or flooding problems.
- In most instances, your builder's advice is likely to be correct, but if you have concerns, then get a second opinion.

Location of the home on the property

- On large properties there may be a lot of flexibility on where a home is located.
- Ideally, buildings should be located outside the 2% (1 in 50 year) flood level, with floor levels raised at least 300 mm above the 1% (1 in 100 year) flood level.
- Consider how stormwater will move across your property, and locate your home away from overland flow paths.
- **Remember;** it is not the council's job to check that your home is correctly positioned.

Style of house construction

- There are various types of buildings, including slab-on-ground, low-set stump construction, and elevated (pole) homes.
- It is important to select the style of building that is most suitable for your block of land with respect to the land slope and flood risk.
- Building costs often focus the home owner's attention towards 'slab-on-ground' construction, but such construction practices should not be the automatic choice on steep properties.

Photo supplied by Catchments & Creeks Pty Ltd

Photo supplied by Catchments & Creeks Pty Ltd

Map of Tempe, Arizona, showing flood-prone areas (Flood Flag Map).

Legend:

- Blue:** Areas with a 1% Annual Chance Flood (ACF) or greater.
- Yellow:** Areas with a 1% to 10% ACF.
- Green:** Areas with a 10% to 100% ACF.
- Red:** Areas with a 100% ACF or greater.
- Blue lines:** Major waterways (Salt River, Tempe Canal, etc.).
- Yellow lines:** Major roads (Loop 101, Loop 202, Loop 190, etc.).
- Black lines:** Other roads.
- Grey areas:** Developed areas.
- Green areas:** Parks and open spaces.

Scale: 0 to 1 mile.

Source: City of Tempe, Arizona. Data provided by the Arizona Department of Water Resources.

City of Tempe, Arizona

Water Resources Department

1000 North Country Club Drive, Suite 100

Tempe, Arizona 85281

Phone: (480) 964-4400

Fax: (480) 964-4401

Website: www.tempe.gov

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Building slab cut into hillside

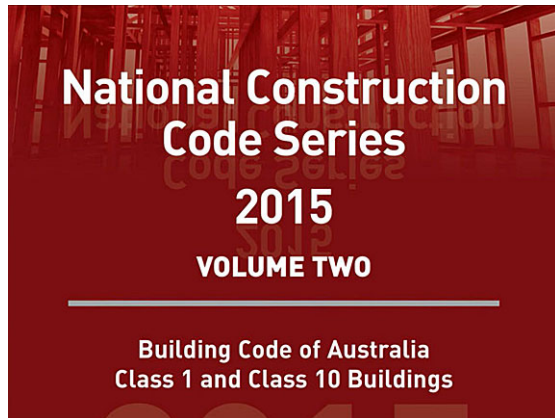
The hydraulic control that governs the depth of water flowing over the building slab may be the land levels at the front of the building

The diagram illustrates a cross-section of a building slab cut into a hillside. The building has a main floor and a lower floor. The ground level is shown as a sloping hillside. A blue line represents the water level, which is shown flowing over the building slab. The text 'Backyard landscaping' is written near the top of the hillside. The text 'Overland flow' is written near the water level. The text 'Overland flow enters lower floor' is written near the bottom of the building, with red arrows pointing to the lower floor. The text 'The hydraulic control that governs the depth of water flowing over the building slab may be the land levels at the front of the building' is written at the top right, with a red arrow pointing to the ground level at the front of the building.

Cutting a building into a hill slope can result in stormwater run-off spilling into/onto any patio, garage or floor that is directly or indirectly connected to an up-slope ground surface

- Slab-on-ground buildings are not the only buildings that have the potential to experience stormwater flooding.
- Any patio, garage or floor level that is potentially subject to the inflow of stormwater run-off needs to be carefully designed to avoid drainage problems.
- Split level homes can sometimes experience stormwater flooding of elevated floors due to stormwater spilling off the adjoining land.

Choosing a minimum floor level



National Construction Code, 2015

3.1.2.3 Surface water drainage

Surface water must be diverted away from Class 1 buildings as follows:

- (b) Slab-on-ground — finished slab heights:
- the height of the slab-on-ground above external finished surfaces must be not less than (see Figure 3.1.2.2) —
- 100 mm above the finished ground level in **low rainfall intensity areas** or sandy, well-drained areas; or
 - 50 mm above impermeable (paved or concreted areas) that slope away from the building in accordance with (a); or
 - 150 mm in any other case.

Explanatory information:

The appropriate slab height above finished ground level and the slope of the external finished surface surrounding the slab may vary depending on:

1. The local plumbing requirements; in particular the height of the overflow relief gully relative to drainage fittings and ground level (to work effectively they must be a minimum of 150 mm below the lowest sanitary fixture).
2. The run-off from storms, particularly in areas of high rainfall intensity, and the local topography.
3. The effect of excavation on a cut and fill site.
4. The possibility of flooding.
5. Termite risk management provisions.

Section 3.1.2.3 (b)

Explanatory information:

The appropriate slab height above finished ground level and the slope of the external finished surface surrounding the slab may vary depending on:

1. The local plumbing requirements; in particular the height of the overflow relief gully relative to drainage fittings and ground level (to work effectively they must be a minimum of 150 mm below the lowest sanitary fixture).
2. The run-off from storms, particularly in areas of high rainfall intensity, and the local topography.
3. The effect of excavation on a cut and fill site.
4. The possibility of flooding.
5. Termite risk management provisions.

Explanatory information for Section 3.1.2.3

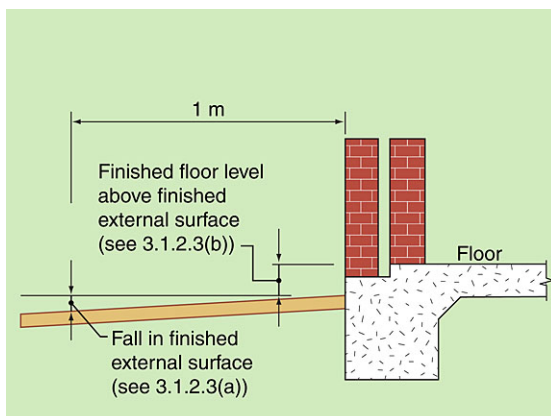


Figure 3.1.2.2

Building codes

- Australian Building Codes Board (ABCB) 2015, *National Construction Code Series – Volume Two, Building Code of Australia Class 1 and Class 10 Buildings*.
- This national building code is referenced within many state and local government building codes, and it guides building designers in the setting of minimum floor slab levels.
- Class 1 buildings include most single-dwelling residential homes.

Height of Class 1 building slabs above ground levels or paved surfaces

- Building designers often refer to Section 3.1.2.3(b) when nominating the elevation of a building slab relative to the adjoining ground or paved surface.
- However, some designers ignore:
 - the 'Explanatory information' which indicates that placing a slab just 50 mm above a paved surface may not be appropriate in areas of high rainfall, and
 - the required 'fall' of the paving (see discussion below).

Circumstances where Section 3.1.2.3 (b) may not be appropriate

- A local government can reject the recommendations of Section 3.1.2.3(b) based on the 'Explanatory information' provided for Section 3.1.2.3.
- In regions where rainfall intensities are high, such as northern Australia (Qld, NT & WA) the 50 mm height above a paved surface may not be appropriate.
- Also, this section does **not** apply in floodplains where minimum floor levels should be based on flood levels.

Required fall of land surface or paving away from the building slab

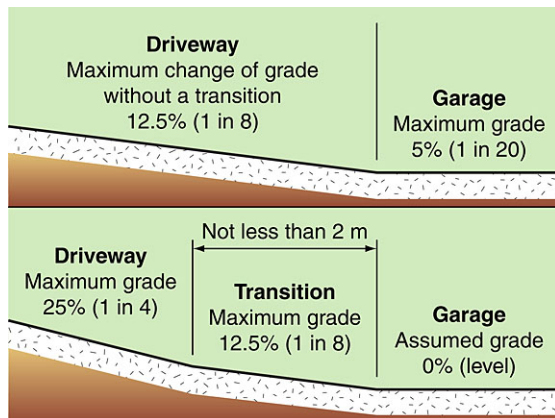
- Section 3.1.2.3(a) specifies that the external finished surface surrounding the slab must be drained to move surface water away from the building, and graded to give a slope of not less than:
 - (i) 25 mm over the first 1 m from the building in **low rainfall intensity areas** for surfaces that are reasonably impermeable (concrete, clay paving); or
 - (ii) 50 mm over the first 1 m from the building in any other case.

Designing your driveway and garage



Photo supplied by Catchments & Creeks Pty Ltd

Driveway with slot-drain drainage system



Change of gradient on steep driveways



Photo supplied by Catchments & Creeks Pty Ltd

Water spilling from a road into a driveway



Photo supplied by Catchments & Creeks Pty Ltd

Slot drain with metal grate

Introduction

- A common location for stormwater entry into a residential building is the garage.
- Drainage problems are more likely to occur if the driveway descends down a steep slope towards the garage.
- Critical design issues are:
 - comply with the design standards of AS2890.1 (slope, height and width)
 - design gradient changes to avoid scraping the underside of vehicles
 - controlling stormwater run-off.

Driveway gradient and change of grade

- This document does not aim to summarise the full design requirements set out in Australian Standard, AS2890.1.
- In general, the design requirements are:
 - maximum recommended driveway gradient on 20% (1 in 5)
 - maximum gradient in garage and across the footpath is 5% (1 in 20)
 - maximum allowable change of gradient is 12.5%, otherwise a minimum 2 m wide transition is required.

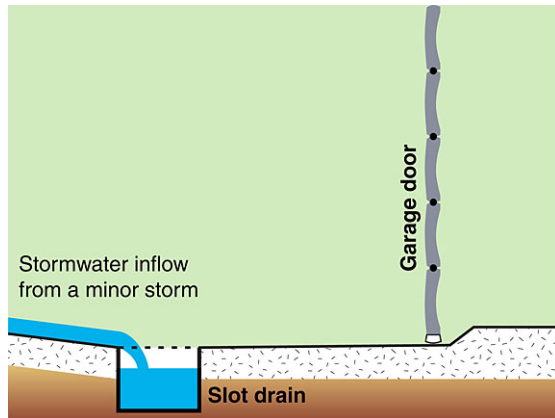
Potential sources of stormwater run-off

- Consider and assess the potential for stormwater run-off to enter the driveway from the following sources:
 - excess stormwater flowing along the street that may spill into your driveway (even if your driveway is not located at a low point along a roadway)
 - stormwater spilling into your driveway because it is located at a low point of a roadway (even if there is a roadside gully inlet adjacent your driveway)
 - rainfall landing directly on the driveway.

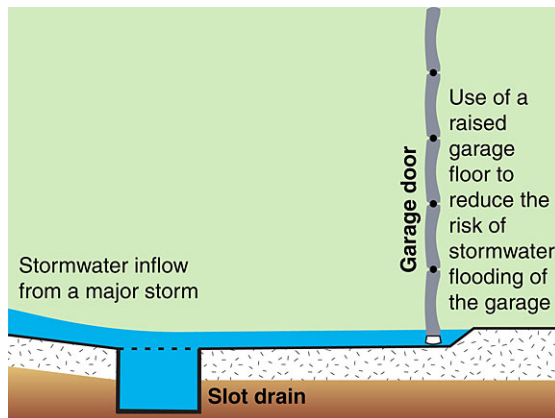
Use of slot drains

- Slot drains are commonly placed in front of garages to capture and redirect stormwater run-off.
- Typically these slot drains can only capture the run-off from minor storms.
- During major storms, stormwater may pass over these drains.
- Caution; the metal grates placed over these drains may need to be treated with a non-slip material to give car tyres grip during wet weather (particularly on steep driveways).

Diverting stormwater away from a garage



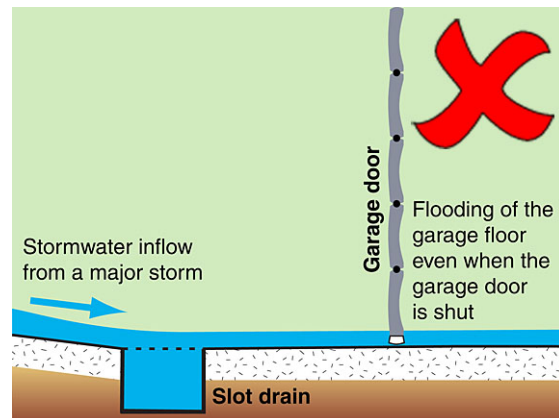
Stormwater inflow during a minor storm



Stormwater inflow during a major storm

Assessing the potential for stormwater flooding of a garage

- Australian Standard (AS2890.1) does not address stormwater issues.
- It is inappropriate to assume that a slot drain placed in front of a garage will prevent stormwater entering the garage.
- At best, slot drains can only manage the run-off from minor storms.
- During major storms it is likely that leaf litter will partially block the drain, and/or the water flow will exceed the drain's hydraulic capacity.



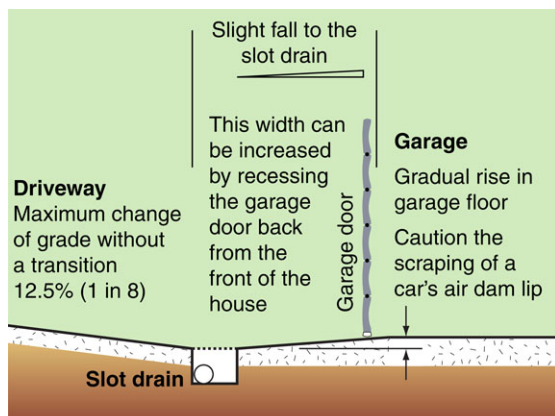
Potential flooding of low-level garage



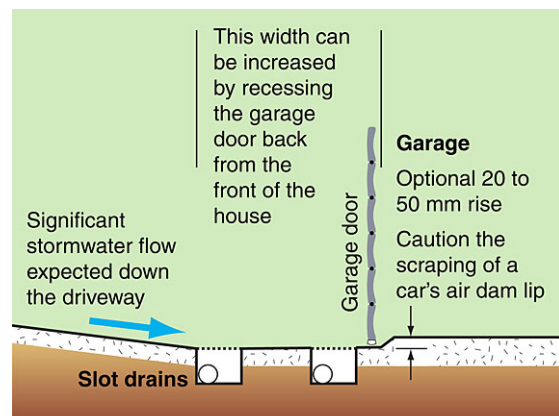
Slot drain located too close to the garage

Designing a mild gradient driveway

- It is not advisable to locate a single slot drain directly in front of the garage door because it will rely on the water seal of the door to prevent water entering the garage.
- If possible, design the driveway to have a low point (and the slot drain) located some 1 to 2 metres away from the garage.
- If the driveway is long, and likely to generate a lot of stormwater run-off, then consider the benefits of a second slot drain, or additional slot drains placed at regular intervals along the driveway.

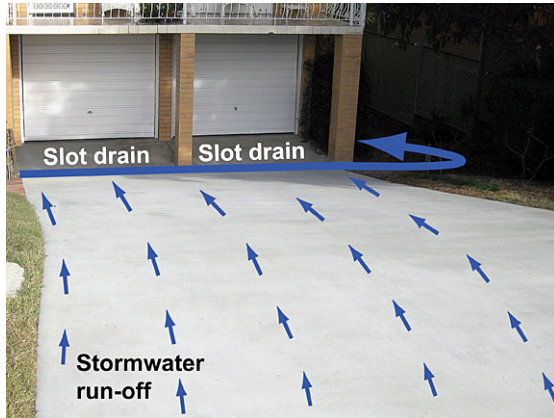


Single drain with gradually elevated floor

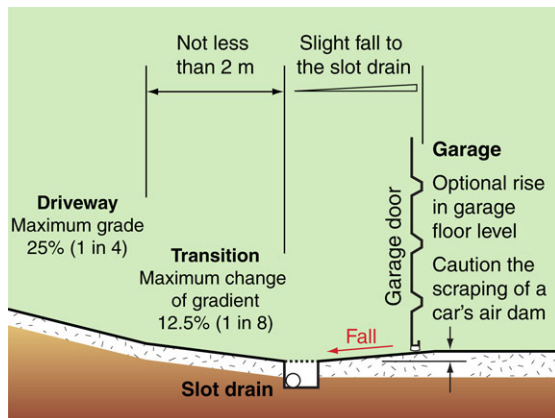


Double drain with elevated floor 'step'

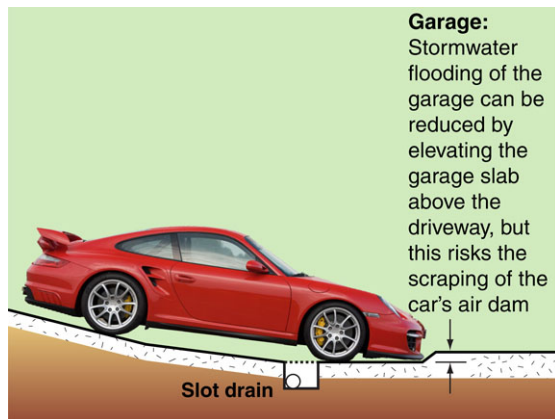
Managing stormwater run-off from a steep driveway



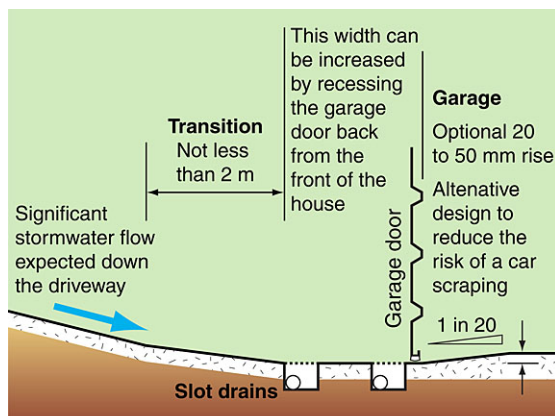
Slot drain located away from the garage



Steep driveway with gradual rise in floor



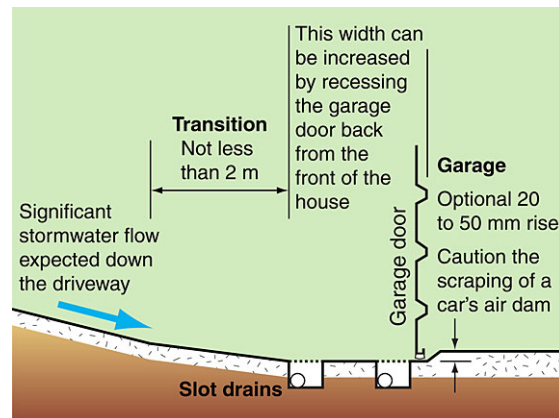
Potential problem of an elevated floor



Alternative, gradual rise in floor level

Managing stormwater run-off from a steep driveway

- If the driveway is steep, then it can be difficult to locate the base of the driveway slope away from the garage door.
- Consider recessing the garage door back from the front alignment of the house to give more room for stormwater to pool and enter the slot drain.
- Also, consider the benefits of slightly elevating the garage floor to help prevent stormwater entering of the garage.



Double slot-drain with raised floor

Checking that the driveway profile is 'car friendly'

- Elevating the garage floor even slightly can **significantly** reduce the frequency of stormwater flooding of the garage, but forming a raised 'step' can potentially cause damage to the underside of motor vehicles.
- If you are designing your own driveway, then consider drawing a scaled side-view of your driveway and garage (ensuring the same vertical and horizontal scales are used), then use a similarly scaled cut-out of your car to check for vehicle clearance.

Alternative design for an elevated garage floor

- If a 20 to 50 mm raised step is likely to scrape the underside of the car, then consider the possibility of a gradual (1 in 20) rise in the garage floor.
- The garage door may be located either side of this short 'ramp' depending on the surrounding architecture (ensuring to avoid the creation of a trip hazard).

Roof and roof drainage systems



Roofing styles



Photo supplied by Catchments & Creeks Pty Ltd

Roof water drainage during a major storm



Photo supplied by Catchments & Creeks Pty Ltd

External, saddle-type bracket



Photo supplied by Catchments & Creeks Pty Ltd

Gutter leaf guard

Choice of roofing

- Several different roofing styles exist, including traditional roof tiles, corrugated metal, and flat roofs.
- Corrugated metal roofing **must** be correctly anchored in accordance with the local building codes to prevent failure during severe wind storms.
- It is important to note that the use of 'sarking' under tiled roofs can reduce the potential for rainwater intrusion into the roof cavity during wind storms.

Roof water drainage

- Storm protection of homes begins with good roof drainage.
- Components of the roof water drainage system include the under-roof sarking, roof sheeting/tiles, and the guttering.
- Gutters are only designed to collect the run-off from minor storms—during major storms it is common for gutters to overtop.
- Different gutter sizes are available—the wider (175 mm) gutters can make the annual cleaning of gutters much easier.

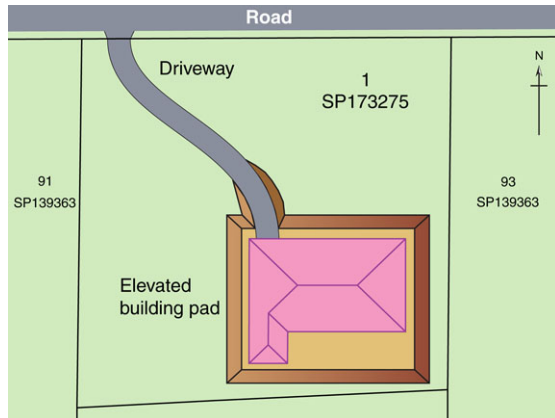
Choice of gutter brackets

- Gutter brackets are used to attach gutters to the roofing frame or fascia.
- There are many different types of gutters and gutter brackets, and some gutters can only be attached with certain brackets.
- External, saddle-type brackets sit below the gutter, and remain visible, but their use can make the cleaning of gutters easier.
- Internal brackets sit above or within the gutter, thus hiding them from view, but these brackets complicate gutter cleaning.

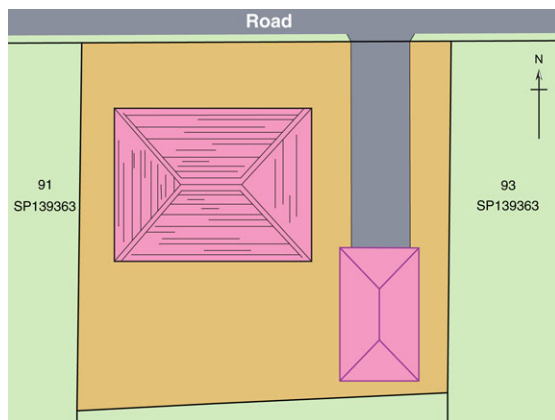
Use of leaf guards

- There are several different types of leaf guards that can be used to reduce the risk of your gutters filling with leaves.
- Most of these products will reduce the hydraulic capacity of the roof drainage system relative to an 'open' gutter, but will reduce the risk of your gutters blocking.
- It is important to note that leaves are not the only things that can be washed off roofs, grit and dirt can still pass through most of these leaf guards and collect within roof gutters.

Use of land filling



Home built on an elevated platform

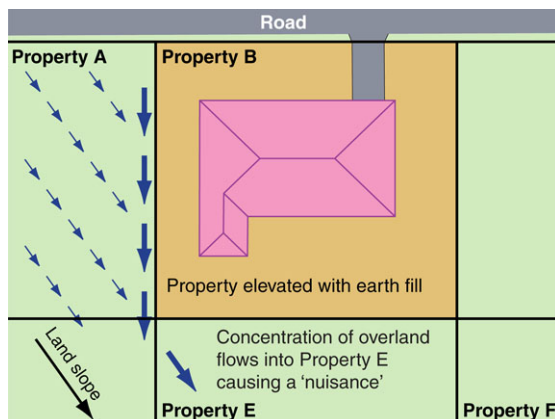


Potentially unlawful diversion of run-off



Water Act 2000

Queensland's *Water Act 2000*



Potentially unlawful diversion of run-off

Elevating a building pad above flood levels

- One of the best ways of avoiding waterway or stormwater flooding is to construct homes that are built in flood-prone areas on an elevated platform.
- An elevated platform is most commonly used when building a slab-on-ground home, but it can also be used when building a high-set home in order to provide an elevated platform under the house to minimise flood damage to the garage, workshop and laundry.

Elevating the full allotment

- Elevating the whole of the property (instead of just the building platform) can potentially introduce some legal problems.
- These legal problems are most commonly associated with:
 - the 'unlawful' redirection of stormwater onto neighbouring properties, and/or
 - a reduction in the flood storage capacity of the floodplain, which can cause an increase in downstream flood levels.
- Refer to discussions later in this document

Legal considerations

- In some local government areas, the filling of land can be considered a 'use of the land' under the council's planning scheme—this may mean that all forms of land filling will require council approval.
- In some states, the filling of any land that is located within a mapped floodplain will be regulated by state legislation (e.g a Water Act or Waterway legislation).
- It is advisable to consult their local government before commencing the filling of your land.

Stormwater and drainage considerations

- If the property is located away from a floodplain, then *Common Law* rules will apply to the filling of the land, which means your land filling must be conducted in a way that does not breach the Common Law rights of your neighbours.
- The Common Law issues that apply to the filling of land are discussed in more detail at the end of this document, but essentially the filling must not concentrate stormwater run-off onto a neighbouring property, or direct such run-off onto a property where it would not otherwise go.

Design of earth retaining walls



Photo supplied by Catchments & Creeks Pty Ltd

Terraced building platforms



Photo supplied by Catchments & Creeks Pty Ltd

Stone pitched wall



Photo supplied by Catchments & Creeks Pty Ltd

Groundwater seepage from a retaining wall



Photo supplied by Catchments & Creeks Pty Ltd

Failure of rock retaining wall

Use of earth retaining walls

- Property filling is usually done in association with the construction of earth retaining walls.
- Earth retaining walls can also be used to level a property to facilitate the construction of a slab-on-ground building.
- 'Cut and fill' earth works involve cutting into the high side of a property and then using this earth to fill the lower side of the property in order to create a level building platform.

Stormwater and drainage considerations

- The critical design issues for earth retaining walls are:
 - location of the wall on either the up-slope or down-slope property
 - required working life of the wall
 - choice of construction material (e.g. timber, concrete block, post & sleeper, stone pitching, rock boulders)
 - subsoil drainage behind the wall
 - maintenance access for moving, weed control, repairs and reconstruction.

Potential problems associated with earth retaining walls

- Potential stormwater and drainage problems associated with earth retaining walls include:
 - groundwater weeping from the wall for long periods after rainfall
 - stormwater run-off redirected by the wall
 - movement or settling of the wall
 - loss of soil or dispersive clay from behind the wall causing slumping (sinking) of the up-slope land.

Potential mass movement of retaining walls

- A critical design feature of any retaining wall is the design of the footings or foundations of the wall.
- If the ground under the wall is unstable, then failure of the wall is almost inevitable.
- Earth retaining walls are engineering structures, and any wall with a height greater than 1 m should be designed by a suitable qualified engineer.

Design of earth retaining walls



Treated timber post wall

Retaining walls with a limited working life

- The effective working life of an earth retaining wall depends on the type of material used to construct the wall.
- Some materials, such as a timber-based products and some decorative concrete post and beam units, have a typical working life of around 20 to 50 years.
- Such products should **only** be used in locations where good long-term access exists, and the full reconstruction of the retaining wall will not undermine house foundations or valued landscaping.



Hardwood sleeper wall



Decorative concrete post and sleeper

Retaining walls with long-term durability

- Long-term durability is best achieved through the use of natural stone.
- Special care **must** be taken when designing retaining walls that are located close to the foundations of either your home or your neighbour's home because of the potential difficulties and high cost of repairing the walls some time in the future.
- Retaining wall located close to building foundations should be made from long-lasting materials such as stone.



Crib wall



Concrete block wall



Boulder wall

Designing a subsoil drainage system



Photo supplied by Catchments & Creeks Pty Ltd

Groundwater seepage from a stone wall



Photo supplied by Catchments & Creeks Pty Ltd

Subsoil drain pipe (ag-pipe)



Photo supplied by Catchments & Creeks Pty Ltd

Drainage 'blanket' placed against a wall



Photo supplied by Catchments & Creeks Pty Ltd

Ag-pipe wrapped in filter cloth

The need for subsoil drainage

- Not all properties require a formal subsoil drainage system; however, most properties will experience some type of 'natural' subsoil water movement.
- A subsoil drainage system is usually needed in the following circumstances:
 - behind retaining walls to reduce constant water seepage
 - adjacent house walls that are recessed into the earth (typically garages)
 - land containing a natural spring.

Who should design your subsoil drainage system

- Subsoil drainage systems can be designed by various people depending on the complexity of the required system.
- Many subsoil drainage systems can be designed and built by people with no formal training, especially with regards to landscaping works and retaining walls.
- However, this is not a component of your drainage system that you want to get wrong, so get a professional opinion if you have concerns.

Two-dimensional drainage 'sheets'

- There is more than one way to design the subsoil drainage system adjacent to walls that are recessed into the earth.
- Systems involving gravel beds and traditional 'ag-pipe' can be used, but increasingly designers are using two-dimensional sheet-like drainage blankets that are attached to the buried wall.
- Manufacturers and distributors often sell both styles, so their literature should guide you to the best choice.

Subsoil drains formed in clayey soils

- If subsoil drains are placed adjacent to unstable clayey soils, then the clayey earth can quickly leach through the aggregate causing land slumping.
- If such clayey soils exist, then it is usually better to first place the ag-pipe (with or without an outer filter cloth sleeve), then surround this pipe with clean (10–15 mm) aggregate, then cover this aggregate with a layer of coarse sand (or topsoil if the in-situ earth is dispersive) such that it separates the aggregate from the surrounding soil.

Design of the minor storm drainage system



Downpipe drainage connection



Free discharge roof water drainage



Grated field (drop) inlet



Slot drain with metal grate

Minor storm drainage system

- Minor storms are those frequent storms that have more than a 10% chance of occurring any given year—these are the storms when an umbrella will actually help to keep you dry.
- Stormwater run-off from minor storms is normally conveyed through a property within a piped drainage system, or as shallow surface water.
- Roof water run-off is normally discharged directly into a piped drainage system.

Disconnected roof drainage systems

- The design of drainage systems for new building works is usually performed by the designer of the building.
- Your plumber may also be aware of specific design requirements that your council may require.
- Design standards can vary from council to council—some councils require the connection of all roof water to the street or to a council drainage system, while other councils allow certain downpipes to release roof water onto garden beds.

Use of field (drop) inlets

- Some councils allow the usage of grated field inlets within the grounds of residential properties, while other councils either resist their usage, or ban their usage.
- These types of stormwater inlets are highly susceptible to debris blockage, especially if they are surrounded by loose organic garden mulch.
- The need for stormwater inlets, such as these, within residential properties has become necessary because of the growing use of solid, impervious fencing.

Use of slot drains

- Slot drains are commonly placed in front of garages to capture and redirect stormwater run-off.
- Typically these slot drains can only capture the run-off from minor storms.
- During major storms, stormwater often passes over these drains.
- The risk of full debris blockage is lower for these drains because of their length—it is unlikely that full debris blockage will occur along the full length of the slot drain.

Design of the major storm drainage system



Overland flow during a major storm

Major storm drainage system

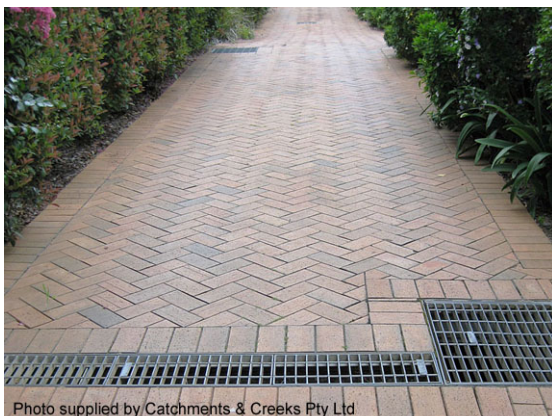
- The drainage of stormwater run-off from major storms is often the forgotten part of the design of residential properties.
- During major storms you don't get to tell the water where to go; instead, it usually tells you where it wants to go, and your home needs to get out of its way!
- Rarely can a piped drainage system handle the run-off generated from major storms; instead, it usually needs to be conveyed through the property over the land surface as 'overland flow'.



Recessed garden path adjacent to a house

Establishing overland flow paths for stormwater run-off

- The design of the major storm drainage system is often forgotten because there is no reference to such drainage systems within the building codes.
- The best way to manage the run-off from major storms is through the intelligent design of the property's landscaping.
- **Every** home should have a well-defined flow path for stormwater run-off that passes around the home and through the property.



Detention tank located below this driveway

Use of driveways to carry overland flows

- In new homes, driveways are often used as 'overland flow paths' that carry stormwater run-off either to the street, or to underground water storage tanks known within the stormwater industry as 'on-site detention' (OSD) tanks.
- If your home is at risk of stormwater flooding, then having a drainage engineer review the design of your driveway could help you to avoid such a flood risk.

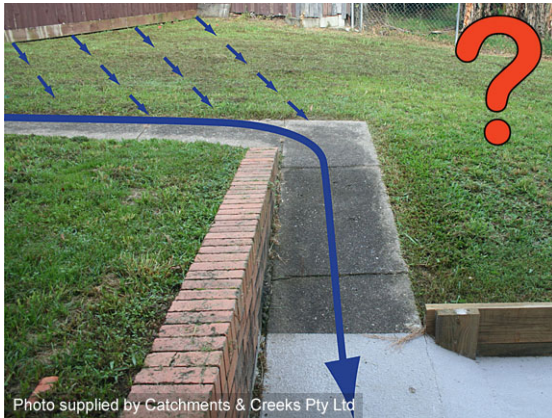


Recessed driveway & overland flow path

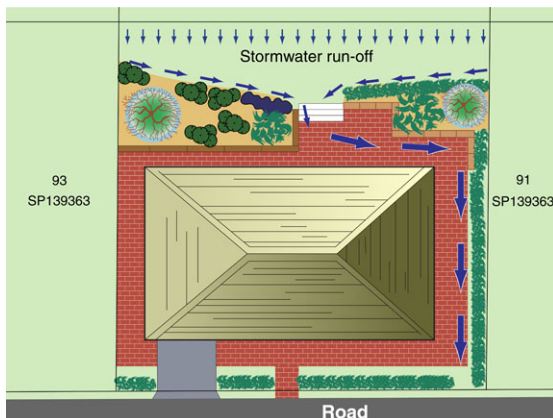
Recessed driveways

- In extreme cases, driveways can be recessed into the ground to ensure that stormwater run-off from major storms does not enter the home.
- In such cases, it is best to park your car in the street, away from the flow path of this stormwater, if a severe storm warning is issued.
- Major storms are those storms that have less than a 10% chance of occurring during any given year.

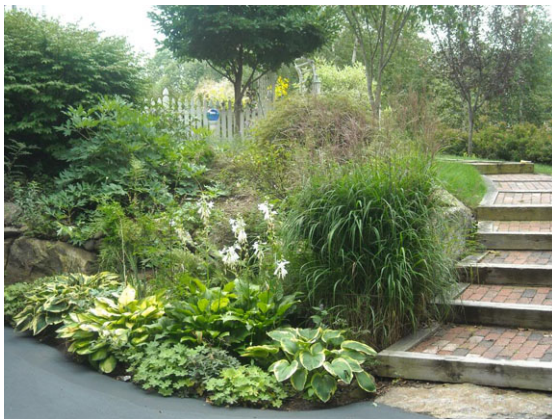
Designing the property's contouring and landscaping



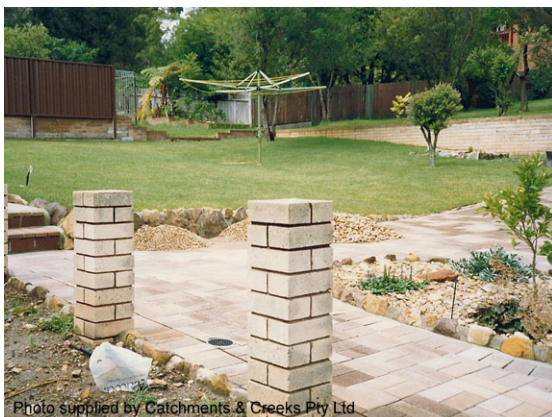
Stormwater directed towards the house!



Ideal property drainage



Backyard landscaping



Overland flow path through a backyard

Property landscaping and drainage design

- Closely linked to the drainage design is the design of the property landscaping.
- On sloping properties it is typical for at least one side of the property to fall towards the house.
- Home owners should avoid landscape designs that may cause stormwater run-off to be collected by pathways or raised garden beds, which subsequently direct this run-off towards doorways (front or rear), garage doors, or patios.

Land shaping measures used to direct stormwater run-off away from a house

- Understandably, most pathways lead to some type of gateway or doorway.
- The key to good landscaping is to use intelligent land shaping that guides stormwater run-off away from the house at key locations.
- This is best achieved by having all pathways pass through a low point (valley) that is located away from the house—this low point being the formal overland flow path that passes around the house.

Landscaping measures that can be used to redirect stormwater run-off

- The passage of stormwater run-off can be redirected using:
 - raised garden beds
 - recessed pathways
 - retaining walls
- An important property of water flow is that the faster the flow velocity, the more resistant the water is to a sudden change in direction; consequently, the steeper the property, the more gently meandering the flow path needs to be.



Simulated overland flow path

Choice of property fencing



Photo supplied by Catchments & Creeks Pty Ltd

Wire mesh fencing

Stormwater and drainage considerations

- As a general rule, stormwater run-off occurs naturally over all land surfaces, except land that is at the very top of a hill or ridge.
- This means most property fences need to allow some degree of through-flow, otherwise the fence will cause the potentially unlawful redirection of any stormwater run-off.
- There are many different styles of property fencing that facilitate the 'natural' movement of stormwater run-off.



Photo supplied by Catchments & Creeks Pty Ltd

Pool safety fencing



Photo supplied by Catchments & Creeks Pty Ltd

Open picket fence



Photo supplied by Catchments & Creeks Pty Ltd

Timber fence with well-spaced paling



Photo supplied by Catchments & Creeks Pty Ltd

Elevated metal panel fencing



Photo supplied by Catchments & Creeks Pty Ltd

Vegetative hedge 'fencing'



Photo supplied by Catchments & Creeks Pty Ltd

Minimal boundary fencing

Choice of property fencing



Drainage reserve overland flow path

Fencing across major overland flow paths

- The design of property fencing needs special consideration when the fence crosses over a major overland flow path.
- 'Major' overland flow paths typically exist along the floor of natural valley lines where stormwater run-off concentrates before flowing down the slope towards a creek or waterway.
- If a fence crosses an overland flow path, then the fence must be designed to allow stormwater to pass under and/or through the fence during major storms.



Photo supplied by Catchments & Creeks Pty Ltd

Wire mesh fencing



Photo supplied by Catchments & Creeks Pty Ltd

Property fence with a swing gate



Photo supplied by Catchments & Creeks Pty Ltd

Raised fencing with lower wire mesh

Fencing across overland flow paths that incorporate animal control features

- The design of a property fence can become very complicated if parts of the fence is required to cross an overland flow path, and the fence is also required to fully contain family pets.
- As a general guide, families that wish to keep family pets, such as dogs or chickens, should avoid purchasing or renting properties that contain a major overland flow path.



Photo supplied by Catchments & Creeks Pty Ltd

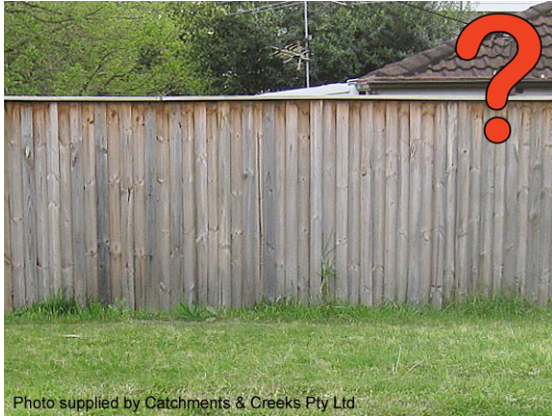
Wire mesh fence with swing gates



Photo supplied by Catchments & Creeks Pty Ltd

Wire mesh fence with swing gate

Choice of property fencing



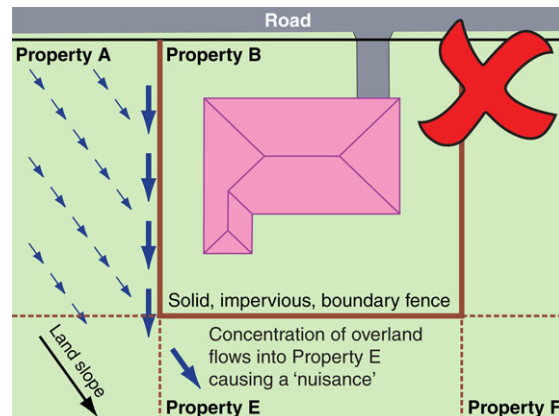
Solid, impervious timber fencing

Potential problems caused by solid, impervious fencing

- There is currently a growing trend to install solid, noise-control fencing that not only reduces traffic noise, but also provides increased privacy.
- In some cases this type of fencing can be a town planning requirement of the local government.
- Before installing any such fencing, residences must consider the potential for the fence to 'unlawfully' divert stormwater run-off into a neighbouring property.



Impervious metal panel fence



Potentially unlawful flow diversion

Property fencing within floodplains

- If the residential property exists within a floodplain, then it is usually necessary for the fence to be designed to collapse so as not to adversely affect flood levels on neighbouring properties.
- In urban areas, the most common type of flood-prone fencing is open wire mesh fencing.
- In rural areas, the most common type of flood-prone fencing is three-strand barbed wire fencing.



Flood damage to a timber fence



Flood debris blockage of mesh fence



Flood debris damage to steel fencing

Part 3: Managing stormwater drainage on your property

Introduction



Photo supplied by Catchments & Creeks Pty Ltd

Approaching thunder storm



Photo supplied by Russell Cuere

Stormwater run-off during a major storm



Photo supplied by Catchments & Creeks Pty Ltd

Major storm run-off



Photo supplied by Catchments & Creeks Pty Ltd

Stormwater discharge to a street

Introduction

- This chapter focuses on how home owners can investigate and resolve drainage problems that may occur from time to time on a residential property.
- Issues discussed include:
 - managing stormwater inflows entering your property
 - managing stormwater passing through your property
 - managing stormwater outflows that discharge from your property.

Stormwater movement across boundaries

- Many residents hold the opinion that it is unlawful for stormwater run-off to spill from one property into another, but this is **not** the case.
- In most situations it is common for stormwater run-off to flow across property boundaries.
- If stormwater run-off flows 'naturally' into your property, then it is your responsibility to design and maintain your property in a manner that prevents this water causing a nuisance within your property.

Managing rainfall that falls on your property, and stormwater run-off passing through your property

- In many cases, stormwater drainage problems only become obvious during major storms, i.e. well after the home is built and landscaped.
- Most drainage problems can be resolved with a bit of 'lateral thinking' and a clear appreciation of how pathways, raised garden beds and recessed drainage lines, can influence the movement of water through a property.

Ensuring stormwater run-off discharges from your property in a lawful manner

- Stormwater will likely discharge from your property as piped flow during minor storms, and as both piped flow and surface run-off during major storms.
- If stormwater discharges from your property into a neighbouring property, then it is your responsibility to ensure:
 - the stormwater leaves your property along its 'natural' flow path, and
 - the flows are not unnaturally, or unreasonably, concentrated.

Managing stormwater water inflows from an up-slope property



Photo supplied by Catchments & Creeks Pty Ltd

Stormwater inflow into a property



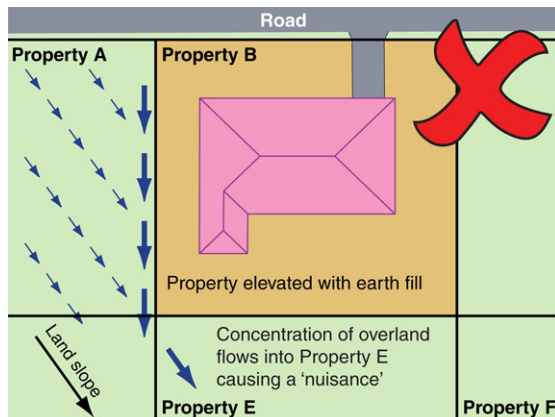
Photo supplied by Catchments & Creeks Pty Ltd

Overland flow during a major storm



Photo supplied by Catchments & Creeks Pty Ltd

Council drainage reserve / footpath



Potentially unlawful diversion of run-off

Lawful inflow of stormwater

The lawful nature of any stormwater inflows that enter your property depends on a number of factors, including:

- Is the stormwater following its natural flow path?
- Is the stormwater being released into a drainage easement that passes through your property?
- Has the up-slope property undertaken any unreasonable measures that have resulted in the concentration of the stormwater run-off onto your property?

The 'natural' flow path of stormwater

- In most cases it is not the responsibility of an up-slope property owner to prevent stormwater discharging from their property, provided the stormwater is following its natural flow path.
- The 'natural' flow path is the path that the stormwater run-off would have taken prior to urban development.
- Even if the up-slope property has a piped drainage system, there is always the risk of a storm exceeding the capacity of this minor-storm drainage system.

Drainage reserves and easements

- In urban areas, efforts are usually taken to minimise the occurrence of concentrated surface flows through private property.
- Instead, preference is given to the use of council-managed 'drainage reserves' that pass between private properties, often disguised as pathways.
- In cases where stormwater run-off from several properties must pass through private property, then it is common for a 'drainage easement' to be obtained over the affected land.

Potentially unlawful actions of an up-slope property owner

- In most circumstances, if person 'A' takes actions that cause harm to person 'B', then person 'A' can be held liable.
- However, in the case of stormwater run-off, the legal rights of person A and person B can be very confusing.
- The rules are not always simple to understand, and readers are advised to seek their own legal advice.
- Some general discussion on common law issues is provided later in this document.

Managing stormwater water inflows from an up-slope property



Photo supplied by Catchments & Creeks Pty Ltd

Council park up-slope of urban properties



Photo supplied by Catchments & Creeks Pty Ltd

Major storm discharge from a roadway



Stop and think!

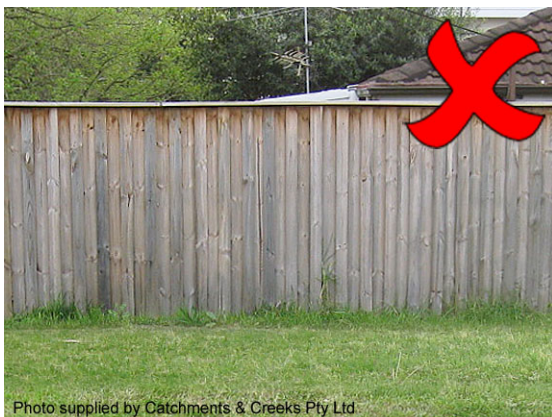


Photo supplied by Catchments & Creeks Pty Ltd

Solid fence blocking overland flows

Flows entering from council land

- If the up-slope property is owned by a government body, such as a local council, then the same laws and conditions apply as for any other property owner.
- In essence, the local council has not more legal obligations to divert stormwater away from your property than any other landowner.
- In practice, most councils try to restrict concentrated stormwater flows to road reserves, drainage reserves, or drainage easements.

Flows entering from a roadway

- Roadways can be owned by a variety of organisations including federal, state and local governments, and body corporates.
- Roadways should be designed such that stormwater run-off is not unreasonably concentrated onto down-slope properties.
- This does **not** mean that it is unlawful for road authorities to release stormwater onto your property, but it must be consistent with the statute or common law requirements that existed at the time of the road construction.

Taking steps to alter or prevent the inflow of stormwater from an up-slope property

- Part 5 of this publication briefly discusses the legal rights of up-slope and down-slope property owners.
- Most importantly, no property should be allowed to act in a manner that would cause stormwater run-off to be diverted into a property where it would not have naturally gone (unless that property is a formal drainage easement or the like).
- In other words, you cannot simply divert the problem towards someone else.

The potential impact of property fencing

- Some property owners try to use solid property fencing to protect their property from up-slope stormwater run-off.
- Such actions can cause neighbourhood disputes resulting in legal action.
- The best approach is to seek your own legal advice, as well as advice from your council and drainage experts.
- During major storms, such fencing can collapse causing property damage and/or cause the flooding of adjacent properties.

Managing stormwater discharges from your property



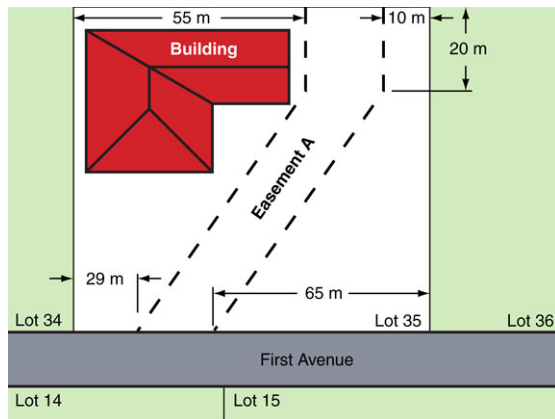
Photo supplied by Catchments & Creeks Pty Ltd

Stormwater outlet to a roadway



Photo supplied by Catchments & Creeks Pty Ltd

Stormwater passage under property fence



Drainage easement



Photo supplied by Catchments & Creeks Pty Ltd

Landslip caused by stormwater discharges

Lawful discharge of stormwater

- The laws that apply to stormwater flows entering your property also apply to stormwater flows leaving your property.
- Neighbours can agree (in writing) to a change in the discharge conditions from one property to another; however, any such agreements do not necessarily negate the up-slope property owner from being liable for any damages caused by such waters.
- Warning; such agreements are not always transferable to future landowners.

Discharging onto private land

Stormwater run-off is allowed to flow across property boundaries provided the stormwater:

- travels along its natural or designated flow path (e.g. along an easement)
- has not been concentrated such that damage is caused to the down-slope property that would not have otherwise occurred
- has not increased in flow rate or quantity beyond that resulting from the normal use of the up-slope land (refer to Part 5).

Discharging onto a drainage easement

Stormwater run-off that discharges into an overland-flow drainage easement is allowed to be increased in concentration, flow rate, or quantity provided:

- such increases are consistent with the operational conditions of the easement
- the stormwater does not cause damage to the easement (e.g. soil erosion)
- the stormwater does not increase damages caused to land or property outside the easement.

Discharging onto freehold land

- Local councils are landowners with the same rights as private landowners.
- If stormwater run-off discharges from your property onto freehold land, such as a council roadway, then the owner of that land (i.e. the council or state) can agree to a change in the flow conditions.
- However, discharging onto freehold land does not prevent the up-slope property from being liable for any damages caused to the freehold land that would not have otherwise occurred.

Properties located down-slope of roadways



Photo supplied by Catchments & Creeks Pty Ltd

A house sitting below the roadway

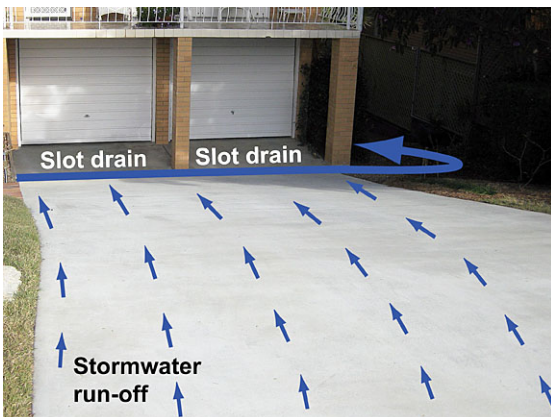


Stormwater passing along a roadway



Photo supplied by Catchments & Creeks Pty Ltd

Driveway lowered below the footpath level



Stormwater diverted away from garage

Properties down-slope of roads

- There is nothing inherently problematic about the drainage of properties that sit below an adjacent roadway.
- In general, the probability of experiencing a drainage problem on a particular property is not normally related to whether or not a property sits above or below the adjacent roadway, but more critically to the way the water is managed.
- Owners of such properties however, should be aware of the unique drainage issues that can apply to such properties.

Roads are designed to carry stormwater

- Most roads are designed to carry stormwater run-off during storm events.
- The pipes that pass under roads are only designed to carry the stormwater run-off that results from 'minor' storms; that being storms that have more than a 10% chance of occurring during any 12-month period.
- The existence of flows passing down a roadway does not necessarily mean that the drainage system is blocked, or that the engineers made a mistake, it could just mean that there was a lot of rainfall!

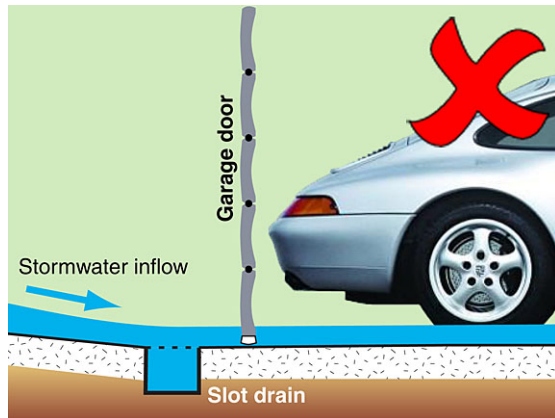
Modified your driveway entrance

- If the property is located below the roadway, then residents need to consider the risk of flows passing from the roadway into their property during major storms.
- The footpath or verge is elevated above the road to reduce the risk of stormwater spilling from the road into the property.
- **Never** recess the driveway or footpath below its original 'as-built' elevation.
- If no footpath exists, then ensure a raised embankment (verge) exists between the roadway and the property.

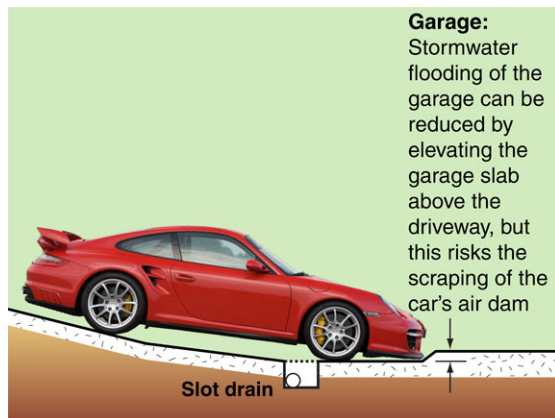
Drainage design adjacent to your garage

- The most common drainage problems experienced on properties that sit below a roadway are those associated with the garage and driveway.
- The garage floor must be raised above the paving that sits directly in front of the garage door—a 'slotted' drain or similar is then placed along this low point to direct stormwater away from the garage.
- Discussion on the design of driveway drainage systems is provided in Part 2 of this document.

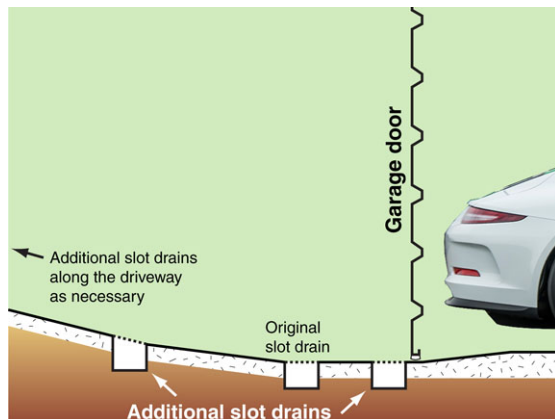
Diverting stormwater away from your garage



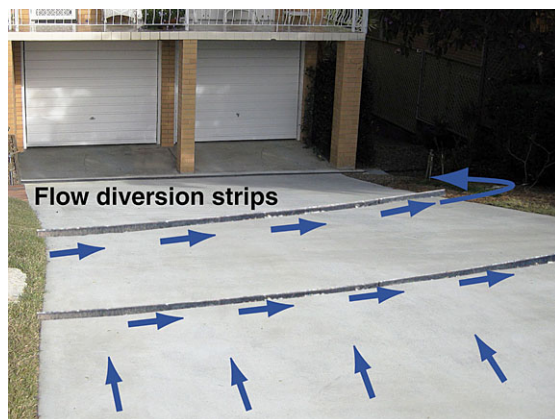
Stormwater flooding of a garage



Potential problem of an elevated floor



Installation of additional slot drains



Flow diversion strips set in a driveway

Corrective measures for garages that currently experience stormwater flooding

- If a existing garage is experiencing stormwater inflows onto the garage floor, then the corrective measures can include:
 - raising the garage floor height
 - installing additional drainage systems along the driveway
 - diverting up-slope stormwater inflows away from the driveway
 - diverting stormwater off the driveway at intermediate points along the driveway.

Elevation of the garage floor

- Concrete or paving stones can be placed over the floor of the driveway to elevate it above possible stormwater levels.
- **However**, it is important to ensure that this is done in a manner that does not cause the front or rear of the car to scrap on the floor while entering or leaving the garage.
- Consider drawing a scaled profile of your driveway and garage (ensuring the same vertical and horizontal scales are used), then use a similarly scaled cut-out of your car to check for vehicle clearance.

Installation of additional slot drains within the driveway

- Additional slot drains can be installed at intermediate points along the driveway to reduce the amount of stormwater run-off that can reach the garage.
- These slot drains can discharge onto the grass adjacent to the driveway, or can be connected to a piped drainage system that is installed along the side of the driveway.
- If the driveway is steep, then check that the slot drains will not cause the car's tyres to lose grip in wet weather.

Diverting stormwater off a driveway

- If the site conditions allow, consider diverting any up-slope stormwater away from the driveway, this could include:
 - inflows from the street
 - inflows from land adjacent to the driveway.
- Alternatively, cut flow diversion slots in the concrete, or install strips of paving or raised rubber flaps along the driveway—these devices need to be installed at a slight angle to the flow in order to divert the water off the driveway.

Diverting stormwater away from a doorway



Flooded doorway

Stormwater entering doorways

- Homes that are located below the elevation of the adjacent roadway can experience stormwater intrusion into the front door if appropriate property drainage is not achieved.
- Homes that are located on sloping land above the elevation of the adjacent roadway can experience stormwater flooding of rear doorways if appropriate land shaping and property drainage is not achieved.



Diversion of stormwater

Diversion of stormwater away from the doorway

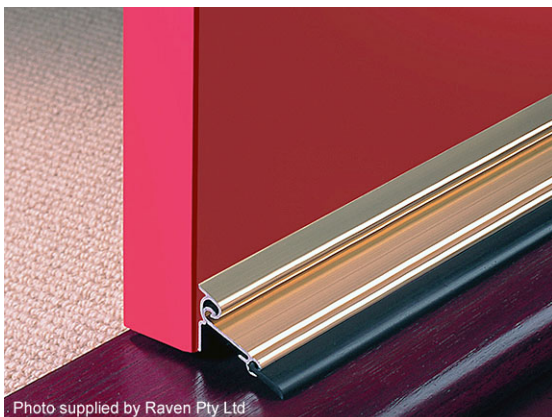
- Stormwater flooding of doorways is possibly more common than river flooding of homes, and this type of flooding can occur on any home if the building or property landscaping are poorly designed.
- Corrective measures can include:
 - redesign the property's landscaping
 - reshaping the land to direct stormwater away from the doorway
 - installation of a drainage system.



Slot drain placed in front of doorway

Installation of a drainage system

- Drainage systems can consist of:
 - slot drains (caution: the potential safety risk to people wearing high heel shoes)
 - an extensive drainage system (possibly using several slot drains) can be installed under the entrance square in front of the doorway, which is then covered with paving stones glued to the drainage grates leaving the edge gaps open (i.e. not filled with grout) to allow the inflow of stormwater (the smaller the pavers, the greater the flow area).



Automatic water seal installed on a door

Water seal 'flap' installed on the door

- If the stormwater intrusion under the doorway is a minor issue, then commercial products exist that can be attached to the base of the doorway to reduce the risk of such problems occurring.

Doorway flood guards



Hydroguard

Temporary doorway flood control devices

- Various commercial systems exist for the **temporary** control of stormwater and floodwater intrusion at doorways.
- Most of these systems require the flow control gate to be manually raised in the event of a heavy downpour.



Watertight flood gate



Flood Angel Flood Defender



Stormguard Floodplan Flood Defences



Image Flood Defence



Floodgate



Hydrosshield

Case study: Solving a drainage problem adjacent to a low-level doorway



Low-set doorway subject to flooding

The problem

- The following is an example of an actual drainage problem at the back door of a two-storey residential property that has been recessed into the hill slope.
- New landscaping of the backyard resulted in land levels being raised to the height of the back doorway.
- During subsequent storms, stormwater run-off pooled on the grass, eventually spilling into the home even though the grass was installed with a gentle slope falling away from the building.

The solution

- The key to solving this a drainage problem is to re-contour the immediate area in a manner that encourages the stormwater to move away from the doorway and around the building.
- It is important to note that during severe storms, stormwater will likely pool some 20–50 mm above the height of the land surface, in this case the grass.
- Note; this solution was only possible because the land adjacent to the house was re-contoured to allow good drainage.



Modified doorway entrance

Forming a recessed pad

- A shallow, recessed concrete pad was formed directly in front of the doorway.
- A raised timber edge (painted white) forms the boundary of this recessed pad—this edge or 'weir' will ensure that there is a fall in the water surface from the lawn onto the recessed concrete pad.
- A gap in the weir allows the recessed pad to drain around the side of the building.
- A thick wire doormat is placed on the pad to reduce the risk of tripping and to form a more gentle passageway into the building.



Flow passage under and around building

Encouraging water to flow around the building

- Along the far side of the building the land has been lowered to form a gravelled overland flow path.
- At the edge of the building a new set of paved stairs has been constructed that will encourage the bulk of the up-slope stormwater to flow away from the doorway and around the building.
- This example represents just one possible solution to a common residential drainage problem.



Stormwater diverted around the building

Managing stormwater run-off passing through your property

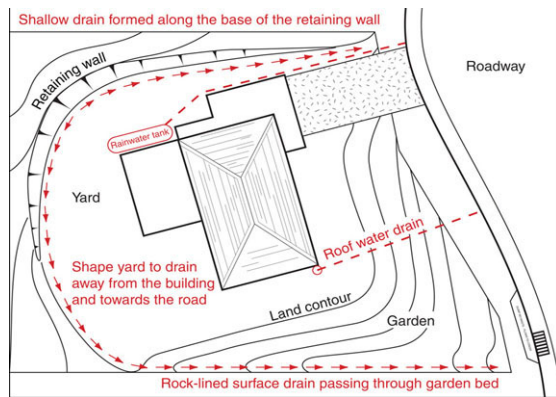


Diagram supplied by Catchments & Creeks Pty Ltd

Property drainage plan



Photo supplied by Catchments & Creeks Pty Ltd

Property landscaping



Photo supplied by Catchments & Creeks Pty Ltd

Rock-lined surface drain



Photo supplied by Catchments & Creeks Pty Ltd

Grated stormwater inlet

Property drainage plans

- The first step to managing your own drainage is to prepare a drainage plan for your property.
- On complex sites the preparation of such a plan may require the assistance of a stormwater or drainage engineer.
- Most councils have policies and building codes that address the drainage requirements of residential properties, but these policies rarely step you through the process of preparing a drainage plan.

Landscaping and pathways

- A common problem experienced on residential properties is stormwater flowing down pathways and driveways.
- When landscaping your property, laying paving, or installing pathways, always consider how it will affect the surface flow of stormwater during major storm events.
- Always ensure that there is a free-draining flow path that can drain surface water away from doorways and around the building—do **not** rely on just a piped drainage system.

Drains passing through garden beds

- If surface drains need to pass through garden beds, then these drains should be lined with rocks (rock mulching) to reduce the risk of organic mulch being washed from your property.
- Grass clippings and organic mulches can cause significant water quality problems within creeks if allowed to wash from your garden bed.
- **Never** dispose of grass or garden clippings within parks, drainage reserves, bushland, or waterways.

Drainage inlets

- Grated stormwater inlets often appear within the yards of residential properties.
- Such inlets are highly susceptible to debris blockage during storms, especially heavy windstorms.
- Given that full debris blockage can occur from time to time at these inlets, wherever practical, ensure that stormwater run-off can bypass a fully blocked inlet without causing the flooding of adjacent buildings or neighbouring properties.

Managing stormwater run-off passing through your property

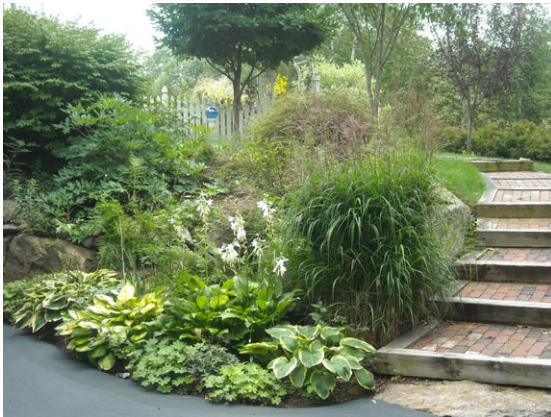


Photo supplied by Catchments & Creeks Pty Ltd

Overland flow

Overland flows

- On some residential properties the surface flow of concentrated stormwater run-off is very rare, while on other properties it can be a regular occurrence.
- When the occurrence of surface flows is common, landowners generally manage their properties accordingly and experience few problems.
- Drainage problems normally occur when residents interfere with the natural flow path of this water, for example, by blocking the flow path with a fence.



Landscaped garden and pathway

Re-directing overland flows

- Property landscaping can be used to gradually 'guide' overland flows around buildings and through your property.
- It is important to respect the needs and preferred flow direction of stormwater run-off when designing the alignment of pathways and stairs.
- **Remember;** overland flows during 'major' storms will always try to follow the natural contours of the land, and may not follow the same path that they travel during minor storms.



Photo supplied by Catchments & Creeks Pty Ltd

Shallow grassed spoon drain

Shallow grassed 'spoon' drains

- Surface flows resulting from minor storms are often best managed through the use of shallow grassed 'spoon' drains.
- These drains can help to direct stormwater run-off away from neighbouring properties and towards the roadway or other suitable discharge point.
- A raised garden bed can also be used along a fence-line to prevent flows spilling into a neighbour's property.



Soakage drains under construction

Use of French drains

- In some regions the bulk of the stormwater run-off can be infiltrated into the soil using French drains or soakage pits.
- A French drain is a deep, rock-filled drain that promotes the infiltration of stormwater (resulting from minor storms) into porous ground.
- French drains may not be effective in heavy clay soils, or in tropical regions where the volume of stormwater run-off regularly exceeds the infiltration capacity of the soil.

Case study: Correcting the problems of poorly designed land contouring



Earth fill placed against lower walls

Home with earth backfilled against the lower walls

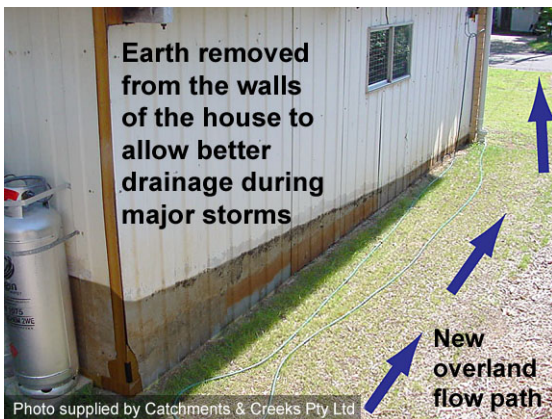
- This is an example of a high-set house that has had the normally open breezeway under the home surrounded with cladding to form non-habitable rooms under the house.
- A stormwater flooding problem was then created when the owners backfilling earth up against the porous cladding.
- During extended periods of wet weather, groundwater would seep from the earth through the cladding into the lower floor.



Earth removed from the rear of house

Bulk earth removal from the property

- Bulk earth was removed from the property to fully expose all the cladding that surrounds the lower building level.
- The brown discolouring of the cladding (this photo and below) identifies the depth of earth that previously rested against the building.



New drainage path around the house

Re-contouring of the land adjacent the building

- The property was then re-contoured to ensure that a clear overland flow path exists around the building.
- The property now drains from the backyard to the street with a grassed flow path that has a gradient of just 1 in 400 (50 mm fall in 20 m), but a steeper gradient would have been preferred.
- An added benefit of this drainage work is the improved ability to inspect all around the building for white ant activity.



Partial landscaping of the backyard

Final landscaping

- Finally the lower floor cladding was repaired and repainted.
- The backyard was landscaped to further direct up-slope stormwater run-off away from the building, including the rear doorway (out of sight in the photo).
- During the landscaping of the property, a new sub-surface stormwater drainage pipe was installed (the white upright is just visible on the right), which will provide a roof water drainage connection when a new rear deck is constructed in the future.

The diagram shows a rectangular property with a red building in the top-left corner. The building has a width of 55 m and a height of 20 m. To the right of the building is a 10 m wide strip. A dashed line labeled 'Easement A' runs diagonally from the bottom-left corner of the property to the top-right corner of the building. The distance from the bottom-left corner of the property to the start of the easement is 29 m. The distance from the start of the easement to the bottom-right corner of the property is 65 m. The property is adjacent to Lot 34 on the left, Lot 35 on the right, and Lot 36 on the right. The property is bounded by First Avenue on the bottom. The property is also adjacent to Lot 14 and Lot 15 on the left.

Photo supplied by Catchments & Creeks Pty Ltd

A photograph of a parking lot with a blue overlay and arrows indicating water flow direction towards a building. The overlay is a light blue shape with two dark blue arrows pointing towards the building. The parking lot contains several cars, including a white SUV and a blue sedan. A metal railing is visible in the foreground. The building in the background has a sign that reads "MELBOURNE".

Photo supplied by Catchments & Creeks Pty Ltd

Managing groundwater seepage problems



Photo supplied by Catchments & Creeks Pty Ltd

Seepage from a boulder wall



Photo supplied by Catchments & Creeks Pty Ltd

Salt damage from rising groundwater



Photo supplied by Catchments & Creeks Pty Ltd

Subsoil drainage behind a retaining wall



Photo supplied by Catchments & Creeks Pty Ltd

Field testing a dispersive soil

Retaining walls

- Retaining walls can often weep groundwater for days or weeks after wet weather if an appropriate subsoil drainage system has not been installed behind the wall.
- Such drainage problems can result in permanently waterlogged lawns at the base of the retaining wall.
- If a seepage problem exists, then a new subsoil drainage system may need to be constructed at the base of, or behind, the retaining wall.

Groundwater seepage problems

- Homes recessed into the earth can experience seepage problems and wall damage if appropriate subsoil drainage systems are not installed behind the walls.
- The appearance of white salt marks on concrete surfaces can indicate subsoil drainage problem—if the marks appear on brickwork, then the problems may be more complex.
- As well as a subsoil drainage system, an impervious seal must be placed on the earth side of walls that form rooms.

Subsoil drainage systems

- Different types of subsoil drainage systems exist including agricultural drainage pipe (ag-pipe) and high-flow plastic sheeting panels.
- In addition to the subsoil drainage system, walls that form rooms need to be coated with impervious sheeting to avoid long-term salt damage and mould.
- Typically you will only get one chance to get the subsoil drainage system right, so seek expert advice if you have concerns.

Stabilisation of dispersive soils

- If the earth behind the retaining wall is dispersive or sodic, then a layer (200 mm thick) of non-dispersive soil must be placed over this dispersive soil **before** the subsoil drainage system is installed.
- Dispersive soils are best identified through professional soil testing; however, a simple field test involves placing hard clumps of the soil into a dish containing distilled water—if the clumps of soil break down and begin to cloud the water, then the soil may be dispersive.

Use of rainwater tanks



Photo supplied by Catchments & Creeks Pty Ltd

Rainwater tank



Photo supplied by Catchments & Creeks Pty Ltd

Downpipe leaf filter

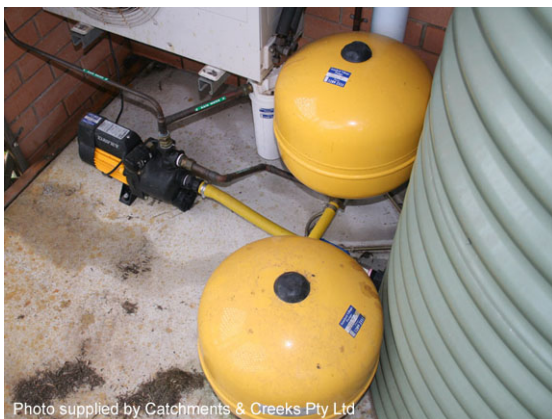


Photo supplied by Catchments & Creeks Pty Ltd

Twin pressure tanks



Photo supplied by Catchments & Creeks Pty Ltd

Cartridge filter

Use of rainwater tanks

- The use of rainwater tanks can contribute to the protection of our waterways and the sustainable use of our water resources by:
 - reducing our dependence on town water supplies
 - providing homes with a secondary water source for toilet flushing
 - reducing erosion problems within urban waterways caused by increased stormwater run-off
 - reducing the adverse impacts of urbanisation on aquatic habitats.

Rainwater tank installation and operation

- All rainwater tanks can overtop, even if standard bypass systems are installed.
- In most urban regions, the tank's overflow pipe must be connected to an approved near-by drainage system so as not to cause flooding of adjacent buildings.
- Leaf filters attached to downpipes can reduce the frequency of tank maintenance.
- If leaf filters are installed, then consider the consequences caused by the debris blockage of these filters.

Use of rainwater

- The allowable domestic use of captured rainwater varies from council to council.
- It is essential to check with your plumber or local council prior to connecting a rainwater tank to any domestic tap fitting.
- All connected pipe work entering the home must be clearly labelled as 'Rain Water'.
- The annual electrical costs of operating a pumping system can be reduced by incorporating one or more pressure tanks.

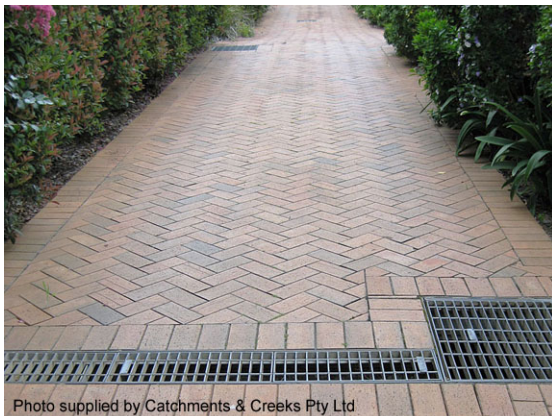
Treatment of rainwater

- Rainwater collected from roofs can become contaminated with various pollutants, including:
 - bird and possum faeces
 - zinc from galvanised roofs
 - dust and leaf matter
 - airborne urban pollutants.
- A variety of filtration systems can be incorporated into the delivery line to improve the quality of the rainwater delivered into the home.

Use of on-site stormwater detention systems



Stormwater detention tank



Detention tank installed under driveway



Stormwater detention on tennis court



Outlet screen inside a detention tank

Purpose of stormwater detention systems

- Though not common in all regions, stormwater detention systems can be used to delay the release of stormwater discharged from domestic, industrial and commercial premises.
- Delaying the release of stormwater can:
 - reduce local flooding problems
 - reduce the potential for erosion within urban waterways
 - reduce adverse impacts on aquatic wildlife within urban waterways.

Installation of detention systems

- On residential properties, stormwater detention systems are usually separate to any rainwater tanks.
- Unlike rainwater tanks, stormwater detention systems are usually designed to fully drain over a period of approximately 24 to 36 hours.
- The use of stormwater detention systems is usually governed by local laws enacted by councils.

Alternative types of stormwater detention

- Stormwater detention systems can take many forms, including:
 - above and below ground tanks
 - rubble or plastic-cell soakage pits
 - enlarged roof water guttering systems
 - recessed tennis courts
 - domestic ponds and dams.
- It is generally **not** considered advisable to utilise the same tank for both stormwater detention and long-term rainwater storage.

Maintenance of detention tanks

- On-site stormwater detention systems should be inspected annually to check for:
 - sediment deposition
 - debris blockage of screens and outlets
 - structural damage.
- Caution; rotting organic matter can generate deadly gasses within tanks that are undetectable to the human nose.
- **Never** enter a confined space without appropriate training, safety equipment, and a second person as an observer.

Protecting stormwater quality on residential properties



Contaminated stormwater discharge



Photo supplied by Catchments & Creeks Pty Ltd

House paint washed into street kerb



Photo supplied by Catchments & Creeks Pty Ltd

Roof and house washing



Photo supplied by Catchments & Creeks Pty Ltd

Car washing on a grassed area

Stormwater drains

- It is important to ensure that only rainwater is allowed to flow into stormwater drains.
- The rule is simple: Never place or discharge anything into the stormwater system that you would not be willing to touch with your bare hands or swim in!
- It is true that our homes and streets look cleaner after a storm, but if we truly respected our waterways, then we should ensure our homes and streets are clean before the storm.

Paints and household chemicals

- **Never** wash paint brushes within a sink that drains to the sewer, or within a drain that flows into the stormwater system.
- Water-based paints certainly provide a lot of convenience for our busy life style, but don't take short cuts when cleaning paint brushes.
- Soak paint rollers and brushes in water over night, then complete the final rinse with a hose such that the wastewater falls onto a lawn or garden bed.

House and carpet cleaning

- Roofs can become contaminated with various pollutants, including bird and possum faeces, dust and leaf matter, and various airborne urban pollutants.
- Disconnect or place plastic film over downpipe outlets before cleaning a roof.
- Carpet cleaning can also release a variety of undesirable chemicals—never discharge the liquid waste down a sink that drains to the sewer, or a drain that flows into the stormwater system.

Car washing

- Soaps and detergents contain chemicals, such as sodium, which can harm waterways.
- If soapy water from car washing is allowed to flow down your driveway or street into the stormwater system, then it can cause turbidity problems within your local creeks.
- Wash your car on grass and allow the excess water to benefit your lawns rather than being discharged to the street.

Protecting stormwater quality on residential properties



Photo supplied by Catchments & Creeks Pty Ltd

Grass clippings dumped over a fence

Disposal of grass and garden clippings

- Never dispose of grass or garden clippings within parks, drainage reserves or bushland.
- This material may be 'natural' in its composition, but it is completely unnatural and undesirable for this material to enter our bushland or waterways.
- Grass clippings quickly break down when they enter waterways causing oxygen to be removed from the water.
- Garden clippings can also release weed species into our parks and bushland.



Photo supplied by Catchments & Creeks Pty Ltd

Pointless personal pollution!

Litter management

- Only lazy people litter!
- Litter is not only an eyesore, but if washed or blown into our waterways, it can cause harm to aquatic wildlife.
- When placing litter into a bin, close enough is **not** good enough—if the bin is full, then it is not acceptable to simply place your litter on or near the bin.
- The existence of a full litter-bin is **not** an excuse to be allowed to litter!
- Remember; only lazy people litter.



Photo supplied by Catchments & Creeks Pty Ltd

Washing down a roadway

Hosing down paths and driveways

- Hosing is often a lazy person's way of sweeping.
- Never hose dirt, litter, grass clippings or chemical spills into a stormwater drain.
- If a path, driveway or road surface is considered dangerous due to the deposition of slippery material (e.g. a film of dirt), then first sweep the excess material from the surface before washing the remaining material onto an adjacent grassed area.



Photo supplied by Catchments & Creeks Pty Ltd

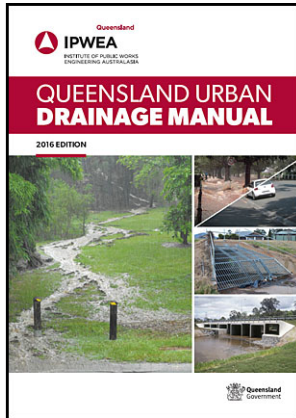
Topsoil placed on a roadway

Building and landscaping works

- All building materials should be delivered and stockpiled within the building allotment, not on the verge or roadway.
- If materials must be temporarily stockpiled on the verge or road pavement, then initially place a sheet of plastic or filter cloth over the land surface to aid in the final clean-up.
- Remember, only your council can give permission for materials to be stockpiled on the verge or road pavement.

Part 4: A general overview of council drainage systems

Local government drainage systems



Queensland Urban Drainage Manual

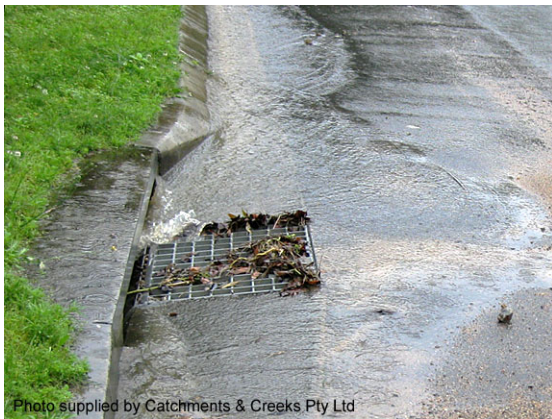


Photo supplied by Catchments & Creeks Pty Ltd

Roadside stormwater (kerb) inlet



Photo supplied by Catchments & Creeks Pty Ltd

Major storm run-off on a roadway



Photo supplied by Catchments & Creeks Pty Ltd

Modified urban waterway (creek)

Introduction

- The design standards for stormwater management in public spaces, such as roads, commercial areas, and parks, are different from the plumbing standards used on residential properties; however, there are many similarities.
- Most actively-used public areas have two parallel drainage systems, one that manages the run-off from minor storms, and one that manages the run-off from major storms.

Minor storm drainage systems

- The minor storm drainage system may consist of:
 - 'sheet' flow drainage on hard surfaces such as car parks
 - surface water drainage swales
 - sub-surface drainage pipes.
- Typically these minor storm drainage systems are designed to carry only the 1 in 2 year to 1 in 10 year storm flows.
- These systems can overflow causing stormwater to flow down roadways.

Major storm drainage systems

- Residential areas are most commonly designed with roadways passing along the natural valley floor so that they can carry the run-off from major storms without causing property flooding.
- If you observe significant quantities stormwater flowing down a roadway, it does not mean the council's drainage system is under-designed, it just means the road is designed to carry such flows.
- Major storm run-off can also pass along drainage reserves and waterways.

Waterways

- Waterways are nature's natural drainage channels.
- Some residents have in the past criticised councils for discharging their stormwater into the local waterway, but this is where stormwater should flow.
- However, urbanisation can damage the integrity of natural waterways, and the natural wildlife that lives in and around these waterways, if the stormwater run-off is not appropriately managed.

Impact of urbanisation on natural waterways



Constructed drainage channel

Piping or channelisation of waterways

- Past engineering practices resulted in the piping of small urban creeks, and the expansion and channelisation of the larger creeks.
- Even today, if flood risks are high in a given area, then there is usually a strong public push to expand and straighten the local waterway.



Creek bank erosion

Increased bed and bank erosion

- Urbanisation causes an increase in the 'volume' of stormwater run-off that occurs during most storms.
- In most cases there is also an increase in the peak discharge released into urban creeks during these storms.
- It is not unusual for an urban creek to widen and deepen to a channel size that is twice the size of the original, pre-urbanisation creek.



Fish kill in an urban waterway

Loss of natural wildlife

- Urbanisation can adversely impact on the natural wildlife by:
 - reducing the area of natural habitat
 - the failure to provide suitable terrestrial and aquatic movement corridors under waterway bridges and culverts
 - the management of controlled bushfires near residential areas
 - the construction of dams and weirs that prevent or severely restrict fish passage.



Sediment-laden stormwater run-off

Reduction in water quality

- Aquatic life within urban waterways is also adversely impacted upon by the effects of polluted stormwater.
- Urban stormwater can be polluted by:
 - litter
 - garden chemicals and fertilisers
 - sediment from building sites
 - tyre wear and brake pad dust
 - sewer overflows
 - unnaturally high inflows of organic matter (leaves, grass, etc.).

Stormwater 'quantity' issues



Urban waterway



Stormwater retention basin



Multi-functional waterway culvert



Urban stormwater treatment wetland

Steps taken by councils to reduce the loss of natural waterways within urban areas

- Modern stormwater management practices try to retain natural waterways within new urban developments.
- If new drainage channels need to be constructed, then the engineering practice of 'Natural Channel Design' is typically used to achieve a final outcome that both looks and behaves in a manner similar to a natural waterway.

Steps taken by councils to reduced the risk of bed and bank erosion within urban waterways

- In the past it was thought that the key to minimising creek erosion was to regulate the 'peak discharge' from new urban areas through the use of detention basins.
- It is currently recognised that the key to minimising erosion in urban creeks is to minimise changes in the 'volume' of stormwater run-off, typically through the use of stormwater retention systems, which includes wetlands and lakes.

Steps taken by councils to return natural wildlife to urban waterways

- The steps taken by waterway authorities to improve the habitats of urban wildlife include:
 - retention of natural waterways in new urban developments
 - designing multi-function culverts that facilitate terrestrial, aquatic and human passage
 - installing fishways at exiting, non fish-friendly waterway structures.

Steps taken by councils to improve the quality of stormwater released into urban waterways

- Modern stormwater practices typically incorporate numerous stormwater quality improvement devices, including:
 - litter screens
 - stormwater infiltration pits
 - vegetated sand filters
 - grass filters adjacent to impervious surfaces such as roadways and car parks
 - wetlands and treatment ponds.

Stormwater 'quality' issues



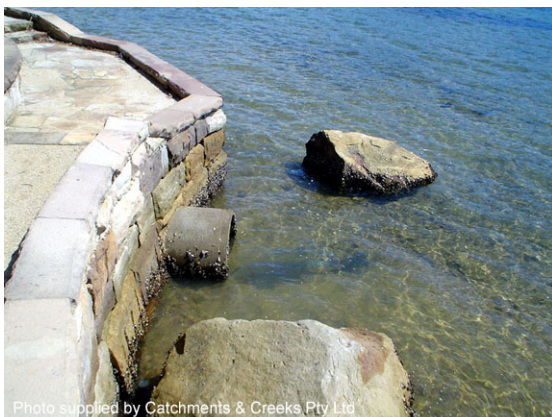
Roadside stormwater inlet



Stormwater outlet



Sewer overflow



Coastal stormwater outlet

The passage of stormwater

- Stormwater does not travel to wastewater treatment plants for treatment.
- In most cases, stormwater passes untreated directly into the nearest creek, waterway or water body.
- In some urban areas, stormwater run-off is filtered by grassed swales or wetlands before being discharged to a waterway, but these systems only treat minor flows, not flood flows.

Discharges to creeks, lakes and rivers

- Most stormwater drainage systems follow the natural valley floor towards an open drain, creek, lake or river.
- The water discharging from urban stormwater pipes is generally considered unsuitable for direct human contact.
- Children should not play within the waters of urban creeks, wetlands or lakes.
- A brown sludge-like material can often be seen discharging from stormwater pipes—this material is not alarming, and is usually a product of iron in the soil.

Sewer overflows

- Almost all sewerage networks have built-in sewer overflow capabilities to ensure the structural integrity of the network and to prevent sewage backing-up into the connected properties.
- Sewer overflows generally occur only during severe storms or power failures.
- When overflows occur during storms, heavily diluted sewage can discharge directly into urban waterways where storm flows further dilute the sewage and carry it downstream.

Coastal waters

- In the days following storm events, coastal waters near urban areas can become polluted by stormwater run-off making the water unsuitable for swimming.
- Coastal waters have very effective natural biological processes that can readily treat most stormwater run-off.
- The safe handling and storage of plastic bags is critical on and around coastal waters where such bags can cause harm to marine creatures.

Regional stormwater treatment systems



Gross pollutant trap



Recessed grassed median



Stormwater treatment wetland



Constructed urban lake system

Litter screens and gross pollutant traps

- It is a growing trend for councils to establish regional stormwater treatment systems within both new and existing urban areas.
- Litter screens and gross pollutant traps have become a 'necessary evil' within our urban areas—their function is to reduce the quantity of litter and organic matter that flows into our waterways.
- Though often unsightly, their existence is essential for waterway health.

Grass and sand filters

- People find it easy to acknowledge the adverse impacts of 'visible' pollutants such as litter, but most of the critical stormwater pollutants are invisible to the human eye.
- Recessed grassed roadway medians help to filter pollutants such as phosphorus, road grime and brake pad dust from stormwater run-off.
- It is important to respect the function of these roadside filters and not to treat them as just another place to park your car or trailer.

Constructed wetlands

- Nitrogen and phosphorus are two of the most common nutrients found in stormwater run-off.
- While much of the phosphorus can be removed by grass and sand filters, the treatment of nitrogen normally requires an aquatic environment such as a bio-filter, lake or wetland.
- Constructed wetlands can be used to treat a variety of dissolved pollutants as well as the removal of fine suspended particles such as sediment.

Urban lakes

- Urban lakes may at first appear to be an aesthetic and recreational feature of many urban landscapes, but they also play an important role in stormwater treatment.
- Urban lakes are in effect large living organisms that undergo many changes both during a given year, and from year to year; consequently these lakes can have their good days as well as their bad days.
- Urban lakes are generally considered unsuitable for swimming.

Public safety around drainage systems



Children playing in roadside drain

Not a place to play

- Flooded streets and drains can appear to be attractive places to play in after a storm, but children have died while playing in flooded drains, creeks and culverts.
- Board riding within flooded drains can result in children being swept into a downstream stormwater pipe or turbulent creek.
- In addition to the physical dangers, the stormwater itself is generally considered unsuitable for direct human contact.



Stormwater drain

Not a place to explore

- Exploring stormwater drains is often considered a part of a normal childhood experience; however, it shouldn't be.
- Children entering stormwater drains can be completely unaware of an approaching thunderstorm that can send an unexpected rush of stormwater down the drain.



Roadside stormwater inlet

Not a place for small children

- It is impossible to make all stormwater systems safe.
- Placing safety screens across stormwater inlets can cause local flooding problems as a result of severe debris blockages.
- Parents and guardians need to be aware of the dangers associated with the stormwater drainage systems in their area.
- Even a roadside stormwater inlet can represent a safety risk to small children swept down the road by stormwater.



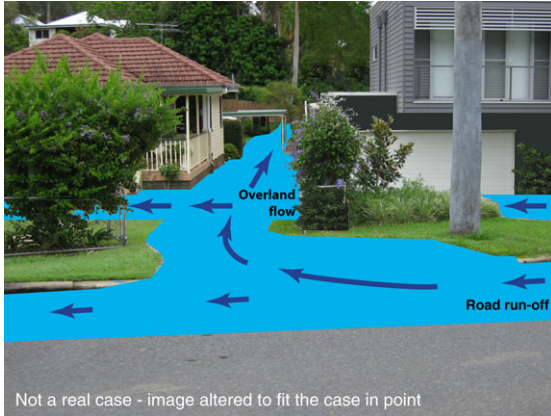
Open stormwater drain

Not a place for anyone

- Constructed stormwater drains often contain hydraulic features to slow the velocity of the water and to dissipate energy.
- These hydraulic features usually represent a significant risk to any person swept down the drain.
- Never play, surf or float down a flooded stormwater drain, creek or waterway.

Part 5: Rights and obligations of landowners and occupiers

Your legal rights and obligations



Not a real case - image altered to fit the case in point

Overland flow entering a property



Photo supplied by Catchments & Creeks Pty Ltd

Local government



Photo supplied by Catchments & Creeks Pty Ltd

Legal profession



Photo supplied by Catchments & Creeks Pty Ltd

Court house

Legal issues

- Stormwater can enter and leave your property at a variety of locations.
- Unfortunately, the laws associated with the movement of stormwater from property to property can be confusing.
- In some cases the 'laws' are found within council policies and state codes, while in other cases the laws rest within the legal framework known as 'common law'.

(The property layout shown left is not a real case, but has been generated electronically for demonstration purposes only)

Involvement by your local council

- In most cases, the best source for advice on the management of stormwater is your local council.
- The laws applicable to drainage systems can vary from time to time and region to region, so the rules that apply to your new home may be different from those that applied to your old home.
- Don't be surprised to hear from your local council that they cannot get involved in neighbourhood disputes, or that they consider the issue to be a private matter.

Obtaining legal advice

- The best place to source 'legal advice' is your own solicitor—friends and neighbours may be a good source of moral support, but usually a poor source of legal advice.
- Warning; legal advice, written or verbal, obtained from a council officer may simply represent that officer's interpretation of the law, and may **not** represent sound legal advice.
- In critical situations it is advisable to confirm all legal advice with your own solicitor.

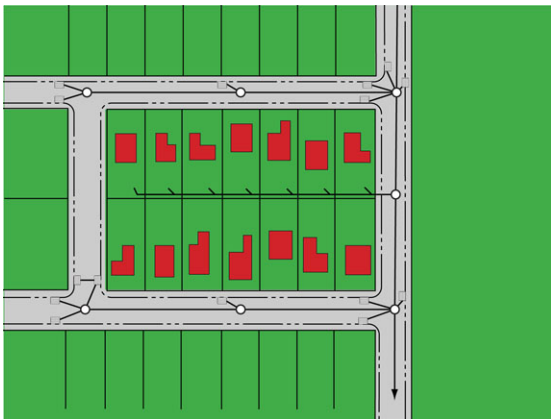
Resolving disputes

- Disputes over stormwater run-off are generally considered a private (civil) matter between the two neighbours.
- Councils generally only get involved if the stormwater discharge originated from a current, or recently completed, building or land development activity.
- The first option should be to resolve all matters through direct and friendly discussions with your neighbours.
- The next option is professional arbitration, and the last option is legal action.

The regulation of stormwater systems by councils



New residential building



Inter-allotment drainage system



Shopping centre



Residential subdivisions

Residential buildings

- In most states, the regulations relating to the drainage of buildings exist within the state's building and/or drainage codes.
- Some councils have specific requirements (local laws) for the plumbing of rainwater tanks and the design of roof-water drainage systems—these rules generally apply to both new buildings and extensions to existing buildings.
- It is usually a legal requirement (?) for all home owners/occupiers to maintain their drainage system in good working order.

Inter-allotment drainage

- Councils can regulate the design of inter-allotment drainage systems during the initial subdivision of land into individual allotments.
- However, the only way councils can control this drainage system after the completion of the subdivision is to obtain easements over the drainage pipes and overland flow paths.
- If easements do not exist, then councils often have limited power to regulate any interference with this drainage system.

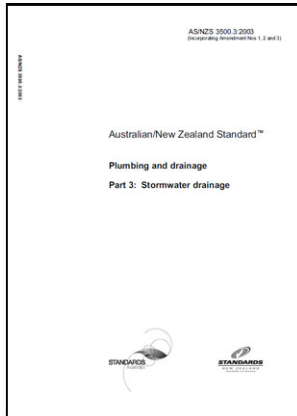
Commercial buildings

- The requirements for drainage systems within industrial and commercial developments often differs from those applied within residential areas.
- Typically these areas are required to have stormwater detention and treatment systems that are far more complex and expensive than those found within residential areas.
- If drainage problems occur in these areas, then the local government is likely to be involved in finding a solution.

Drainage in new subdivisions

- A council's best opportunity to regulate stormwater drainage is during the establishment of new subdivisions.
- New subdivisions typically have fewer drainage problems than older areas of cities and townships.
- If you have concerns about the impact that a new subdivision may have on the drainage through your property, then the best time to resolve these issues is before the subdivision is finished, not after the building approvals have been finalised.

The regulation of stormwater systems by councils



Stormwater drainage standard



Photo supplied by Catchments & Creeks Pty Ltd

Roof water drainage on a new building



Photo supplied by Catchments & Creeks Pty Ltd

Surface release of an 'old' downpipe



Photo supplied by Catchments & Creeks Pty Ltd

Extension to an existing building

Building and plumbing codes

- Stormwater drainage standards for Australia are contained within the combined Australia/New Zealand Standard AS/NZA 3500.3 (Part 3: Stormwater drainage).
- This is a design standard that your council may refer to within their local regulations; however, your council may choose to adopt an alternative standard.
- Reference to this Australian Standard may also be contained within a state's building or development codes.

Drainage from new buildings

- The stormwater drainage system for a new home could be designed by your building designer or your plumber.
- The rules and regulations applicable to these drainage systems may be defined within state building codes and/or council regulations.
- Many councils refer to the stormwater drainage requirements contained within AS/NZS 3500.3 (Part-3: Stormwater drainage) or the Building Code of Australia.

Drainage from old buildings

- In general, the drainage regulations applicable to existing buildings are those regulations that existed at the time of the building's approval.
- This means that some older buildings may have drainage systems that do not comply with current building codes.
- However, if nuisance is being caused to a neighbouring property by an old-style drainage system, then the council may direct the property owner to connect the downpipes to a near-by drainage network.

Drainage from home extensions

- In general, the stormwater drainage of a new home extension must comply with the current drainage regulations of the local council.
- This means that the roof water drainage from a home extension usually needs to be connected to a recognised drainage network, such as a council roadway or an inter-allotment drainage system.
- The over-flow systems from new rainwater tanks also need to be connected to a recognised drainage network.

The application of 'common law' rights in drainage disputes



Photo supplied by Catchments & Creeks Pty Ltd

Australia's High Court, Canberra

Common law

- 'Common law' is a legal system that gives weight to the principle that it is unfair to treat similar facts differently on different occasions—thus judges' decisions in active cases are informed by the decisions of previously settled cases.
- The common law system (known also as 'case law') forms the basis of the Australian legal system.
- **Note:** common law is only applicable in the absence of relevant 'statute laws', including local building codes.



Photo supplied by Catchments & Creeks Pty Ltd

Urban watercourse

Laws applicable to 'watercourses'

- In most states the laws applicable to watercourses have been modified by statute law, and thus the principles of common law are unlikely to apply.
- Each state has its own definition of what constitutes a watercourse, and in some cases these definitions can vary from region to region within a given state.
- Approval is usually required from the state before works can be carried out within the banks of a watercourse, or for the damming or relocation of a watercourse.



Photo supplied by Catchments & Creeks Pty Ltd

Overland flow

Laws applicable to 'overland flow'

- The common law principles applicable to overland flows (i.e. stormwater run-off) are different from those applied to a watercourse.
- The leading court case that outlines the common law principles applicable to the management of overland flows passing across property boundaries is *Gartner v Kidman* (1962) 108 CLR 12.
- An overview of these common law principles is provided within the following pages.



Photo supplied by Catchments & Creeks Pty Ltd

Flows caused by a water pipe failure

Application of the common law principles

- The following common law principles relate only to surface waters which came naturally upon the land from which it flows, as distinct from water artificially brought or concentrated there and allowed to escape.
- These laws are therefore not applicable to cases such as a bursting water pipe.
- **Note:** the following discussion on common law principles has been provided from an 'engineering' perspective (i.e. that of the author) and may not be representative of the opinion of the legal profession.

Common law principles applicable to overland flows

Common law principle

- The owner or occupier of an up-slope property is not liable merely because surface water flows naturally from their land on to lower land.

This means:

- Unless otherwise required by statute laws, it is acceptable for stormwater run-off to flow naturally down a slope.
- The existence of a property boundary does not necessarily make this 'natural' passage of surface water unlawful.
- This common law principle does not necessarily apply if statute laws (government enacted laws) exist that stipulate an alternative stormwater management outcome.

Common law principle

- The owner or occupier of an up-slope property may be liable if such water is caused to flow in a more concentrated form than it naturally would.
- The proprietor of the down-slope land may recover damages from, or in appropriate cases obtain an injunction against, the proprietor of the higher land who is liable to an action because he has concentrated or altered the natural flow.

This means:

- This means that the focus is on taking all reasonable and practicable measures to maintain the 'natural' flow conditions of stormwater run-off as it passes from one property to another.
- Stormwater may be considered to have been 'caused to flow in a more concentrated form than it naturally would' if the flow has increased in peak discharge, peak velocity, flow volume, or flow per unit width, at any particular point, relative to the flow conditions that would naturally occur.
- This does **not** mean that any form of flow concentration is unlawful.
- Some minor flow concentration may be considered to be lawful if it is the direct result from the 'normal use of the land', and this flow concentration is no more than is considered reasonable in order to achieve this normal use of the land.
- For example, if a 'reasonable' property fence exists between two properties, and if the normal operation of this fence causes the temporary concentration of flows (e.g. as a result of partial debris blockage during a storm), then such a temporary concentration of flow would be consistent with the normal use of the land.
- However, the fact that a concentration of flow has been tolerated in the past by a down-slope property owner/occupier does not mean that corrective measures may not be required some time in the future to minimise the risk of future impacts.
- For example, if roof water from an up-slope building causes nuisance to a down-slope property, then the council may direct the up-slope property owner to connect the building to a nearby council drainage system even though the building has existed in its current state for some time.

Common law principles applicable to overland flows

Common law principle

- If a more concentrated flow occurs simply as the result of the 'natural' use of an up-slope property, then generally speaking, the owner or occupier of that property is not liable.
- What is a natural use is a question to be determined reasonably having regard to all the circumstances, including the purposes for which the land is being used and the manner in which the flow of water was increased: as for example whether it is agricultural land drained in the ordinary course of agriculture, whether it is timbered land cleared for grazing, whether it is a mining tenement, or is used for buildings and so forth.

This means:

- These statements reinforce the previous discussion that some forms of flow concentration may be considered lawful if they are no more than what would be expected from the normal use of the land.
- The 'normal use of the land' depends on issues such as:
 - the 'zoning' of the land as defined within a council planning scheme
 - the types of lawful land use activities commonly associated with the land
 - the normal changes, from time to time, that exist in the operation of the land as a result of the normal maintenance of those items that can influence the flow or concentration of stormwater run-off.
- This means that the owner/occupier of an up-slope property would not necessarily be held liable for damages caused to a down-slope property as a result of the normal debris blockage of roof gutters or stormwater inlets that may occur from time to time on the up-slope property.
- However, the owner/occupier of an up-slope property **may** be held liable for damages caused by the concentration of stormwater flows resulting from the 'negligent' maintenance of their stormwater drainage system.
- In essence, this means that there is an obligation on the up-slope property owner and/or occupier to:
 - take all reasonable measures to minimise any adverse impacts on down-slope properties caused by the normal use of their up-slope land.
- Similarly, there is an obligation on the down-slope property owner and/or occupier to:
 - take all reasonable measures to design, manage and defend their property in a manner that allows existing and future owners and occupiers of up-slope lands to operate their land for normal lawful purposes.
- For example, building a home on a vacant up-slope residential property would be considered a normal use of the land, and it would be considered normal for this activity to have some impacts on stormwater run-off from that property. However, the up-slope property owner must take reasonable steps to minimise any such adverse impacts resulting from the building of their home.

Common law principles applicable to overland flows

Common law principle

- Stormwater is considered to be flowing in a more concentrated form than it naturally would if, by the discernible work of man, the levels or conformations of land have been altered, and as a result the flow of surface water is increased at any particular point.

This means:

- This statement outlines **one** example of circumstances that could result in the unnatural concentration of flow.
- This example relates specifically to the land form changes applicable to the High Court case of *Gartner v Kidman* (1962) 108 CLR 12 to which these common law principles were applied.
- However, this does not imply that this is the only means by which stormwater can be flowing in a more concentrated form than it naturally would.
- The trial judge in the case of *Alamdo Holdings Pty Ltd v Bankstown City Council* (2003) 134 LGERA 114, found that even a significant increase in the frequency with which land will be inundated can constitute a significant interference with the use and enjoyment of land, and hence could give rise to an actionable nuisance.

Common law principle

- The proprietor of higher land is not liable for a more concentrated flow from their land if it is the result of work done outside their land by someone else, and for the doing of which they are not responsible, as for example by the paving and guttering of public roads by municipal authorities.

This means:

- This statement acknowledges that the owner or occupier of an up-slope property cannot be held liable for an increase in stormwater flow, or a concentration of such flow, if such changes have resulted from flows entering their property from a third property or from an adjoining roadway.
- This means that complaints about the concentration of stormwater run-off entering a down-slope property can become very complex if the immediate up-slope property is not the sole source of this stormwater run-off.
- For example, an up-slope property owner should not be held liable for damages caused by an increase in stormwater run-off if the source of this increase in flow can be directly linked to land development activities carried out up-slope of their property.
- However, the above statement is only applicable if the third property is not under the management or ownership of the owner or occupier of the immediate down-slope property through which it flows before damaging a further down-slope property. For example, when several up-slope properties are owned or managed by a single person or entity.

Common law principles applicable to overland flows

Common law principle

- The previous statements concerning the concentration of surface waters relate to cases when the increased flow results from work done when the higher land and the lower land were held by separate proprietors.
- Different considerations apply when the lower land receives a concentrated flow as the result of work which was done when it and the higher land were in the same ownership and possession.

This means:

- An up-slope property owner cannot claim immunity from prosecution simply because the increased stormwater flow originated from an adjoining up-slope property if both properties are owned by the same person.
- This common law principle highlights that the resolution of stormwater disputes is critically linked to two factors:
 - the current ownership of the associated allotments, and
 - the ownership of the allotments at the time that the drainage system was installed, and/or the stormwater-altering activities were conducted.
- Consequently, when documenting a stormwater complaint, it is very important for the complainant to establish a time-line of activities, and to identify the ownership of each of the associated allotments at each stage of this time-line.
- This common law principle also highlights that the owner or occupier of a down-slope property is unlikely to have a legitimate complaint about the damages caused to their property as a result of stormwater flows discharging into their property from an up-slope property or council roadway if:
 - the drainage system was established at the time of the original land sub-division when both properties existed as a single property, or
 - the drainage system was established at a time when both the roadway and down-slope property were owned or managed by a single entity.
- It is therefore advantageous for councils to ensure that all stormwater infrastructure is constructed during the initial sub-division of the land while all affected properties are under the control of a single entity.

Common law principles applicable to overland flows

Common law principle

- Although the lower proprietor has no action against the higher proprietor because of the natural unconcentrated flow of water from the up-slope land, they are not bound to receive it.
- The lower proprietor may put up barriers and pen it back, notwithstanding that doing so damages the upper proprietor's land, at all events if the lower proprietor uses reasonable care and skill and does no more than is reasonably necessary to protect the enjoyment of their own land.
- But the lower proprietor must not act for the purpose of injuring their neighbours.
- It is not possible to define what is reasonable or unreasonable in the abstract. Each case depends upon its own circumstances.

This means:

- In effect, these common law principles set out two important outcomes:
 - the owner or occupier of a down-slope property must design, maintain and defend their property in a manner that does not unreasonably prevent the owner or occupier of an up-slope property enjoying the normal use of their up-slope land, and
 - the owner or occupier of an up-slope property must design, maintain and defend their property in a manner that does not unreasonably prevent the owner or occupier of a down-slope property enjoying the normal use of their down-slope land.
- This means that:
 - the existence of an drainage problem within a down-slope property should not necessarily prevent further development, or the conducting of stormwater-altering activities, within an up-slope property, and
 - when building a home or landscaping a property, the owner or occupier of that property must consider, and account for, likely changes in stormwater flows caused by their neighbour's normal use of their land, such as the building of a home, and
 - a down-slope property owner or occupier can take reasonable steps to defend their home, swimming pool or other normal uses of their land against stormwater run-off even if this causes unavoidable adverse impacts on the up-slope property from which the stormwater was discharged.
- A very important principle noted here is that while defending your property from the effects of stormwater run-off, you can **do no more than is reasonably necessary** to protect the enjoyment of your land.
- No property owner or occupier should be allowed to act in a malicious manner, or adopt a damaging course of action, if a reasonable alternative exists that allows their neighbour the continued enjoyment and use of their land.
- **Warning:** this clause is easy to misinterpret, and readers are advised to seek professional legal advice if they feel this clause is relevant to their situation.

Common law principles applicable to overland flows

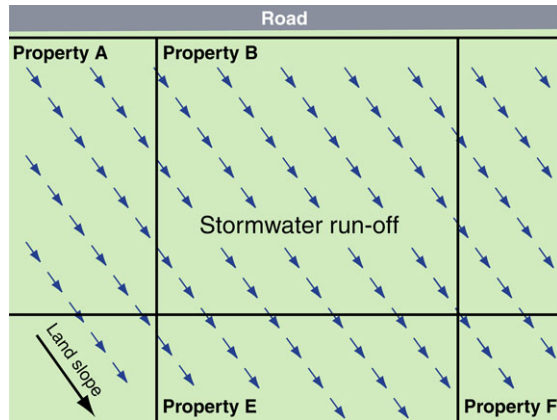
Common law principle

- It may be added that the proprietor's right to defend their land against water coming upon it by erecting barriers, is generally speaking restricted to penning it back on to the higher land whence it would otherwise have naturally come.
- It does not entitle them to divert it on to the land of a third proprietor to which it would not have naturally gone to the damage of that proprietor.

This means:

- This final principle is very important in an urban context because stormwater run-off often flows naturally, in a diagonal alignment, across several residential properties, and as a result, can cause disputes between the numerous property owners.
- The owner or occupier of a down-slope property can defend their property and the enjoyment and use of their land from the adverse impacts of stormwater run-off provided they:
 - cause the flow conditions of the stormwater run-off to be altered only on their land, and/or on the land from which the stormwater run-off would otherwise have naturally come
 - do no more than is reasonably necessary to protect the enjoyment of their own land
 - do not cause the stormwater to be diverted onto the land of a third proprietor to which it would not have naturally gone
 - do not cause the stormwater to be diverted in a manner that causes the flow to be unnaturally concentrated, or to travel along an unnatural flow path.
- Of course, almost any change in the management of stormwater flows can occur lawfully if all affected parties (including regulatory bodies) agree to the proposed changes.
- However, it is noted that a verbal or even a written agreement can be lawfully withdrawn at any future date, and that such agreements are not necessarily binding after a change of ownership of the land.
- Consequently, residents are advised to obtain agreements in the form of a registered easement that is attached to the land, rather than a verbal or even written agreement that is linked only to the landowners that made the agreement.

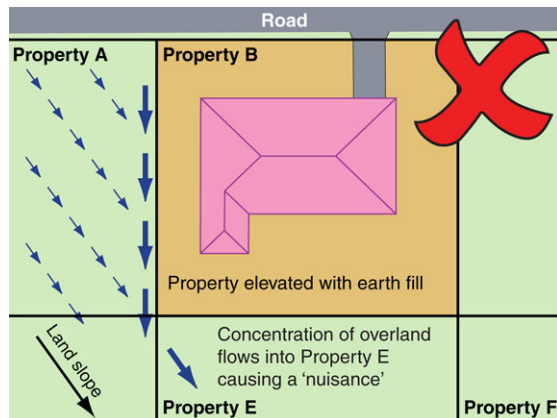
Examples of lawful and potentially unlawful land filling



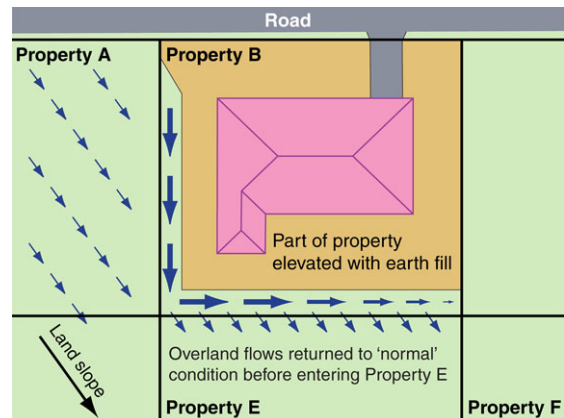
Case 1: Flow conditions prior to land filling

Land filling that interferes with the 'natural' movement of stormwater run-off

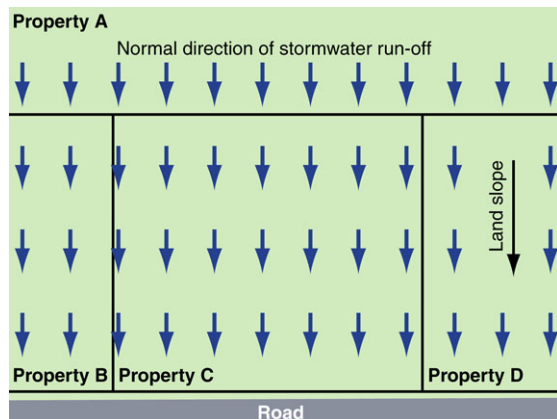
- In the long-term, land filling can provide lasting benefits to the community by permanently removing homes from a potential flood risk.
- However, it is important to make sure that the filling of one property does not result in the redirection of stormwater run-off in a manner that causes a nuisance to adjacent properties.
- This is a complex issue, and the solutions are often just as complex.



Potentially unlawful diversion of run-off



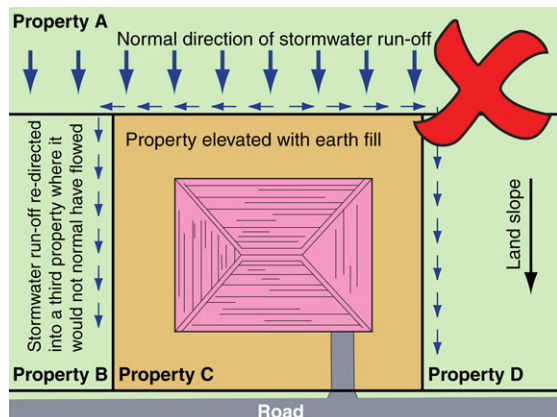
Possible lawful use of land filling



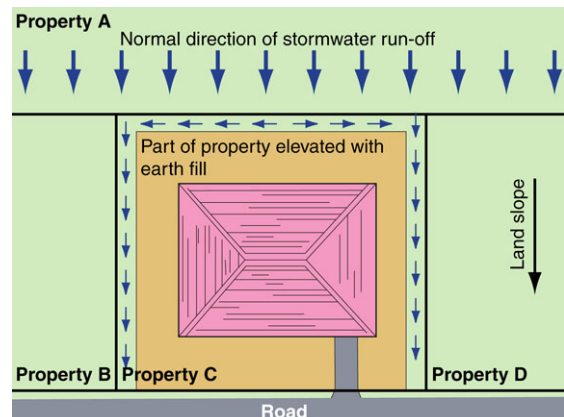
Case 2: Flow conditions prior to land filling

Potential problems arising from the filling of a down-slope property

- The impacts of land filling can in many circumstances be the same as the effects of installing a solid, impervious, boundary fence.
- If your intention is to 'defend' your property from the adverse effects of stormwater run-off, then this must not be achieved by diverting the stormwater onto a third property (i.e. a property onto which the stormwater would not have normally passed).

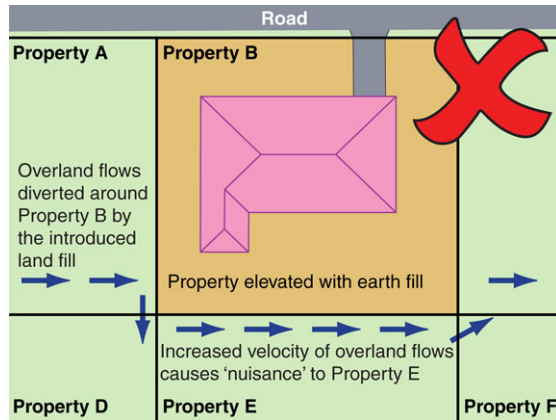


Potentially unlawful diversion of run-off

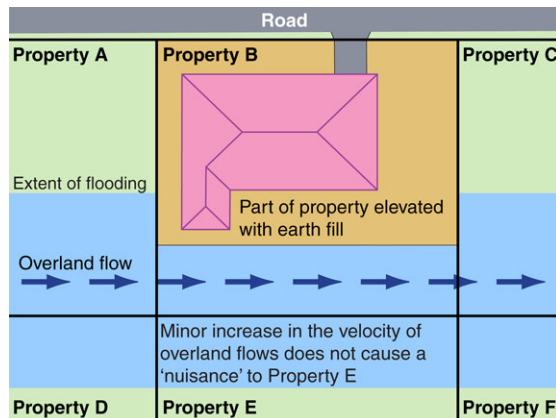


Possible lawful use of land filling

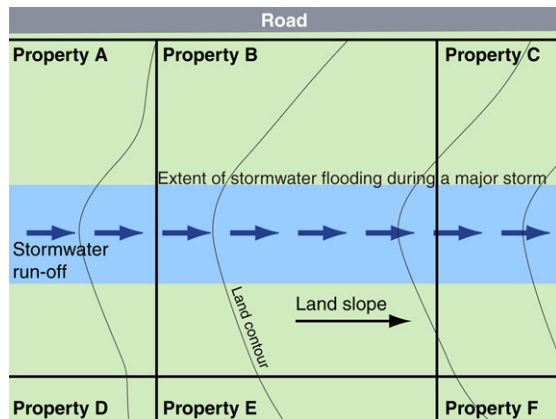
Examples of lawful and potentially unlawful land filling



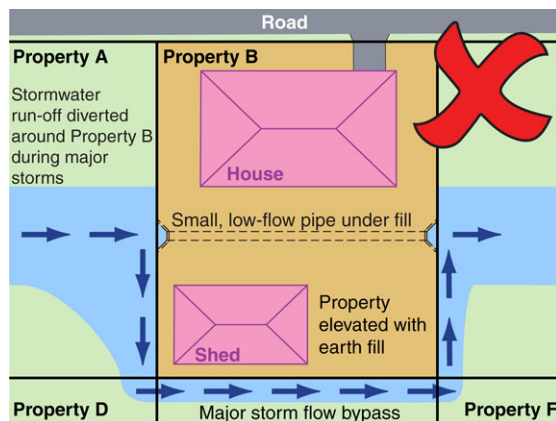
Case 3: Potentially unlawful land filling



Possible lawful use of land filling



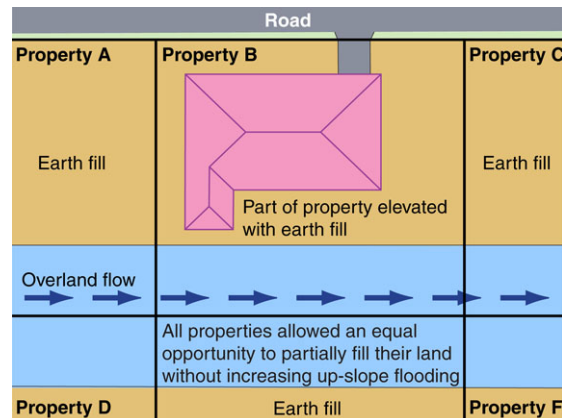
Case 4: Flow conditions prior to land filling



Potentially unlawful blockage of a flow path

Land filling that interferes with a major overland flow path of stormwater run-off

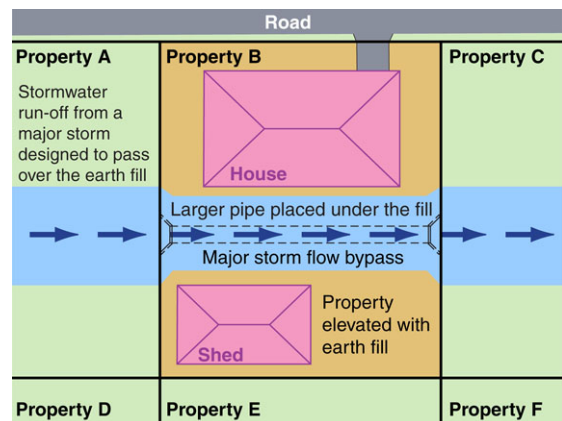
- Council planning schemes may identify long-term land filling proposals that aim to provide all flood-prone residences with the opportunity to elevate their properties.
- Common law principles do not support the concept of 'first in, first served'.
- The filling of one property must:
 - allow other properties to do the same
 - not cause a nuisance on properties that have not yet elevated (filled) their land.



Land filling utilised on all properties

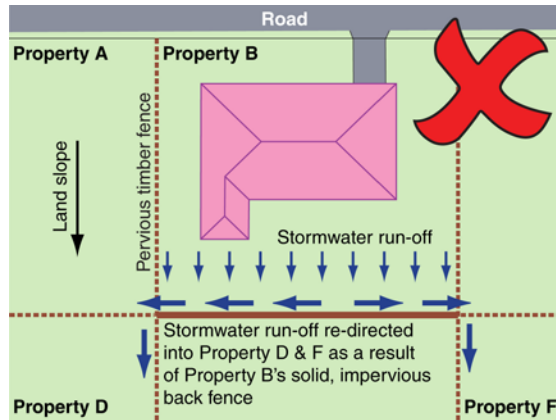
Potential problems arising from land filling over a major overland flow path

- If land filling is proposed to partially block an overland flow path, then:
 - establish a piped drainage system under the fill to manage the run-off from minor storms, and
 - establish an overland bypass for major storm run-off.
- **Never** build over an overland flow path without providing an alternative overland flow bypass in the event that debris blocks the underground drainage system.



Possible lawful use of land filling

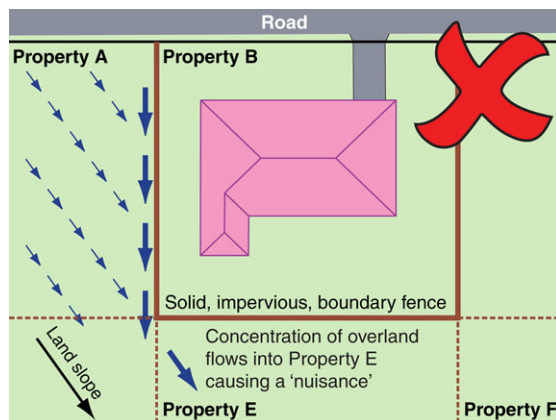
Examples of potentially unlawful property fencing



Potentially unlawful diversion of run-off

The redirection of stormwater run-off by a boundary fence

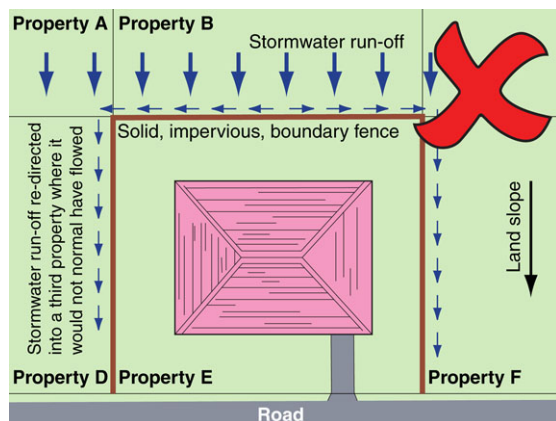
- Solid, impervious fencing is increasingly being used by property owners to:
 - provide increased visual privacy
 - reduce noise transfer
 - reduce the risk of weed/plant growth across property boundaries
- A negative aspect of solid fencing is its potential to redirect natural stormwater run-off.



Potentially unlawful diversion of run-off

The redirection of stormwater run-off by a boundary fence

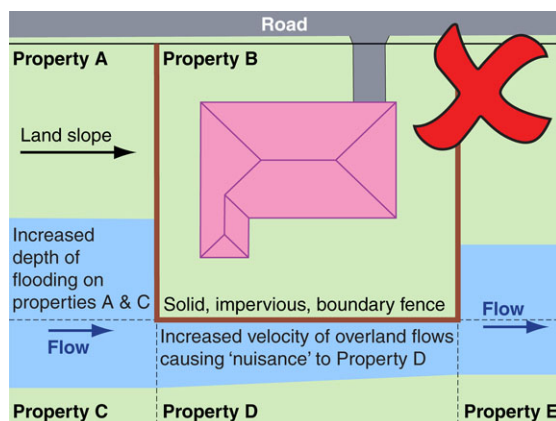
- Modern residential property landscaping typically places garden beds adjacent to the boundary fence rather than adjacent to the building (in order to discourage white ant activity, and to allow building inspections for white ant activity).
- If a solid boundary fence is installed with a gap left under the fence, then over time this gap can become blocked by garden mulch resulting in the undesirable redirection of stormwater run-off.



Potentially unlawful diversion of run-off

The redirection of stormwater run-off by a boundary fence

- Common law principles allow a down-slope property owner to 'defend' their property from the damaging effects of stormwater run-off; however, the boundary fence must not:
 - divert the stormwater onto the land of a third proprietor to which it would not have naturally gone, or
 - unnecessarily cause nuisance to the up-slope property if an alternative type of 'pervious' fence could be used.

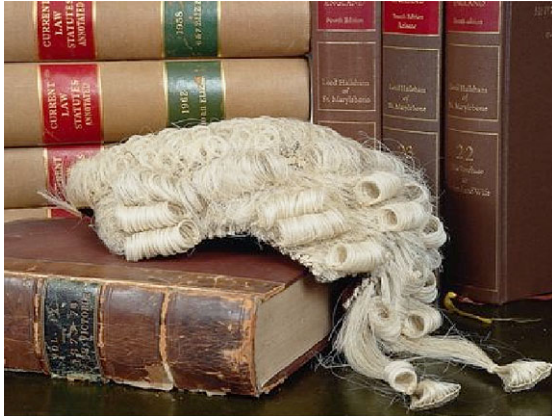


Potentially unlawful diversion of run-off

Property fencing that interferes with the natural passage of concentrated overland flows

- Concentrated overland flows typically occur (naturally) along the invert (base) of natural land depressions and valleys.
- This type of flow 'concentration' is lawful because it is the natural response of stormwater run-off on such land.
- Property fencing must not cause the additional concentration of this flow if the effects are to cause nuisance or damage to an adjacent property.

Actionable nuisance



Legal action



Concentrated stormwater run-off passes under the fence causing soil erosion

Stormwater flows causing soil erosion



Stormwater from new developments diverted into the 'unused' backyard of a neighbouring property

Potentially unlawful concentration of flows



Photo supplied by Catchments & Creeks Pty Ltd

Stormwater run-off

Taking legal action against a neighbour

- In order for legal action to be taken against a neighbour, there needs to be either:
 - an actionable nuisance, in which case the legal action becomes a private dispute between neighbours, which may or may not involve the regulator that approved the building works, or
 - a failure by a neighbour or entity to comply with existing laws, in which case the legal action is normally undertaken by the relevant authority.

Actionable nuisance

- In order for legal action to be taken against the concentration of stormwater run-off, or the worsening of property flooding, the plaintiff needs to demonstrate that an actionable nuisance has occurred.
- An actionable nuisance is an unlawful interference with a person's use or enjoyment of their land, or of some right over their land, such as:
 - soil erosion
 - flooding of buildings that has increased in duration, frequency or severity.

Actions that may alter the 'value' of a property

- In some cases, the actionable nuisance may not relate to your current use of the land, but instead may adversely affect the 'value' or 'future use' of your land, e.g.
 - if a neighbouring property diverts stormwater onto a part of your property that you currently do not use, put could use in the future, or
 - such actions may adversely affect the value of your land or the potential for you to develop the land in the future.

Absence of an actionable nuisance

- In the absence of an 'actionable nuisance', it is not unlawful for a neighbouring property to discharge stormwater run-off onto your property, or to alter the flow of stormwater run-off onto your property, so long as the neighbour does not act in malice, and takes reasonable measures to minimise the risk of a nuisance being caused.
- **Readers are again advised to seek their own legal advice relevant to their specific circumstances, which may vary from that described above.**

Part 6: Terminology

Glossary of terms

1% storm	A storm that has a 1% probability of being equalled or exceeded within any 12 month period at a given location. Such a storm is likely to produce 1% flood levels in a given central region, but lower than 1% flood levels away from the centre of the storm.
1 in 100 year storm	<p>A storm that has a 1% probability of being equalled or exceeded within any 12 month period at a given location.</p> <p>Similarly, a 1 in 10 year storm has approximately a 10% probability of being equalled or exceeded within any 12 month period, and a 1 in 50 year storm has a 2% probability of being equalled or exceeded within any 12 month period.</p> <p>However, a 1 in 1 year and 1 in 2 year storm does <u>not</u> have a 100% or 50% probability (respectively) of being equalled or exceeded within any 12 month period.</p>
Actionable nuisance	A nuisance of such significance that it is likely to cause harm to a person, or cause an adversely affect to the value or use of a person's property (<i>this is <u>not</u> a legal definition likely to be used in a court</i>).
Ag-pipe	A flexible, perforated, corrugated drainage pipe used in agricultural sub-drainage. Also known as an AGRICULTURAL (SUB-DRAINAGE) PIPE.
Backwater flooding	Land flooding that involves the spreading of floodwaters laterally into partially-isolated, low-velocity rivulets or areas of a floodplain.
Bio-filter	A stormwater treatment swale or shallow detention system that combines vegetative filtration, soil infiltration and sub-surface filtration through a filter medium.
Building codes	Design codes used by the building industry.
Codes	A publication typically providing technical regulations and specifications that are specifically linked to legislation.
Common law	Common law (also known as case law) is a collection of 'laws' that have been developed by judges through past decisions of the courts, as opposed to statutes (federal and state laws) adopted through the legislative process.
Concentrated flow	<p>[1] Flow that is not considered to be flowing as 'sheet flow'.</p> <p>[2] Flow that has increased in peak discharge, velocity, frequency, volume, or flow per unit width, at any particular point, relative to a specified point in time or flow condition, such as the 'natural' flow condition, or the pre-development flow condition.</p>
Creek	A watercourse, minor in comparison to local rivers, whether natural or artificial, permanent or ephemeral, with static or flowing water that is fresh, brackish or salty. Natural in its appearance and ecological function, and with a significant ecological association with adjacent riparian vegetation.
Cut and fill allotment	A process of slope modification in which soil is excavated from along one section of a slope and then used to construct an adjoining embankment, usually to form a level building platform.
Detention system (stormwater)	Any stormwater detention management system—basin, parking lot, depressed grassy area, rooftop storage, buried or aboveground tank—used to temporarily detain stormwater for the purposes of delaying or attenuating outflows from that location.
Detention tank	Any stormwater detention management system used to temporarily detain stormwater for the purposes of delaying or attenuating outflows.
Dispersive soil	A soil that is structurally unstable in water, breaking down into its constituent particles (sand, silt and clay) and consequently allowing the dispersive clay fraction to disperse and cloud the water.

DIY	Means: do it yourself.
Downpipe	The stormwater pipe, usually vertical, that carries roof water from roof gutters to either the ground surface or a sub-surface drainage system.
Drainage	<p>A natural or artificial means of intercepting and removing surface or sub-surface water.</p> <p>It is noted that in 'plumbing codes' the term 'drainage' often refers to the drainage of sewage or wastewater.</p>
Drainage easement	A state-registered corridor of land where the drainage function is protected by a documented agreement between the landowner and holder of the easement.
Drainage reserve	A state-registered corridor of land where drainage is its primary purpose and the holder of the easement is either a local or state government.
Easement	A right held by one person to make limited use of another person's land, e.g. right of access to water. For example, a drainage easement is a corridor of land of which the drainage function is the primary role.
Field inlet	A stormwater inlet to a sub-surface drainage system located within an open area where the water falls vertically into the connecting chamber.
Fill	Earth used to elevate a section of land, or the action of filling land.
Filter cloth	A synthetic material that allows water and some soil particles to pass through it. The size of soil particles held back depends on the material grading. It is typically used as a protective lining for earth structures to separate two soils of different soil textures (particle size).
Flood-free home	A home located above the elevation of the probably maximum flood (PMF), therefore not subject to creek or river flooding. However, this does not mean that the home cannot be subject to flooding as a result of rainwater or stormwater intrusion.
Flooding	The inundation of land or structures by water.
French drain	A trench loosely backfilled with rock so that water can flow between the rocks. These drains promote water movement along the drain as well as encouraging infiltration into the adjacent soil.
Geotechnical	Of or pertaining to the practical applications of geological science in civil engineering, mining, etc.
Grate	A grid of metal or other material used to prevent debris from entering a drain or pit while allowing pedestrians and possibly vehicles to pass safely over the opening.
Gross pollutants	A stormwater contaminant that would be retained by a 5 mm mesh screen, usually consists of litter and organic debris.
Groundwater	The water beneath the surface of the ground.
Habitable room	Non-habitable rooms includes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy rainfall	Rainfall with an intensity greater than a locally specified value that distinguishes it from 'light' or 'moderate' rainfall. For example, rainfall with an intensity equal to, or greater than, 10 mm/hr.
High-set home	A building where the lowest habitable floor level is elevated above the ground such that a substantial air gap exists between the building's floor and the ground.

Inter-allotment drainage	A constructed, usually sub-surface, drainage system that exists within the bounds of at least two property allotments, and operates for the purpose of transporting stormwater from the individual allotments to a common discharge point.
Kerb inlet	A grated and/or side-flow weir stormwater inlet located within the kerb of a road. Also known as a SIDE INLET and GULLY INLET.
Lawful	A term generally used when referring to issues relating to the law, e.g. 'a lawful activity'.
Lawful point of discharge	A point of discharge which is either under the control of a local government or statutory authority, or at which discharge rights have been granted by registered easement in favour of the local government or statutory authority, and at which discharge from a development will not create a worse situation for downstream property owners than that which existed prior to the development.
Legal	A term generally used when referring to issues relating to the legal profession, e.g., 'a legal opinion'.
Low-set home	A building where the lowest habitable floor level either has direct contact with the ground (e.g. slab-on-ground) or is elevated only slightly above the ground such that floor level flooding may still occur.
Major storm	A storm with a frequency usually less than 1 in 2 to 1 in 10 years. The definition and critical storm frequency may vary from region to region.
Minor storm	A storm with a frequency usually greater than 1 in 2 to 1 in 10 years. The definition and critical storm frequency may vary from region to region.
Natural flow path	The flow path that water would have taken prior to human interference.
Nuisance (private)	<p>The unlawful interference with a person's use or enjoyment of land, or of some right over, or in connexion with it (Winfield on Tort, 6th ed. (1954) p. 536).</p> <p>or</p> <p>An unreasonable interference with the use and enjoyment of land: an invasion of the common law rights of an owner or occupier of land (<i>Hargrave v Goldman</i> (1963) 110 CLR 40 at 60 per Windeyer J.)</p>
On-grade (kerb) inlet	Stormwater inlet formed in the kerb of a roadway where the roadway has a positive longitudinal grade (i.e. water approaches the inlet from only one direction).
On-site detention	A stormwater detention system that manages the detention of stormwater run-off released from a single allotment or a group of properties developed by a single land developer.
OSD	Means: on-site detention.
Overland flow	Any surface run-off whether flowing as sheet flow or shallow concentrated flow e.g. flow within road reserves, shallow grassed channels and over-bank flows, but not flowing within deep drains, drainage channels or streams.
PMF	<p>Means: probable maximum flood.</p> <p>The PMF defines the extent of land subject to creek or river flooding.</p>
Pole home	A high-set home where timber poles are used to elevate the home above the ground such that a substantial air gap exists between the building and the ground.
Practicable	Capable of being put into practice, being done, being effected.
Practical	Generally the combined consideration of the practicability of an action <u>and</u> the reasonableness (e.g. financial viability) of that action.

Private certifier	A non-government regulator that certifies (approves) building or plumbing works in accordance with state legislation and local government codes.
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, resulting from the probable maximum precipitation (PMP) and, where applicable, snowmelt, coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions.
Property drainage	Rainwater, roof water and stormwater drainage of a property, which includes any constructed sub-surface drainage system.
Retention system (stormwater)	Any stormwater collection systems that <u>retains</u> a portion of the stormwater inflow either for water quality treatment benefits, or to assist in reducing the volume of run-off discharged from the system.
River morphologist	An engineer or scientist that specialises in the study of river behaviour with respect to its physical characteristics and the changes of these characteristics over time.
Rock mulching	<p>The application of a thick blanket of rocks, aggregate or gravel on the soil surface. The term 'rock mulching' normally refers to the use of large rocks with little or no fines, with the mean rock size based on the expected overland flow velocity.</p> <p>The term 'gravelling' normally refers to the application of gravel, which includes fines, on roads and car parks.</p>
Roof water	Stormwater run-off released from roofs.
Run-off	That part of rainfall, snow or hail not lost to infiltration, evaporation, transpiration or depression storage that flows from the catchment area past a specified point.
Sag (kerb) inlet	Stormwater inlet formed in the kerb of a roadway where the roadway has a zero longitudinal grade (i.e. stormwater can approach the inlet from the section of road/kerb located to the left and right of the inlet).
Sarking	A layer of boarding or sheeting material laid under tiles, shingles, or slates for reflective insulation or enhanced water-proofing.
Severe storm	Rainfall with an intensity greater than a locally specified value that distinguishes it from 'heavy' rainfall. For example, rainfall with an intensity equal to, or greater than, 50 mm/hr (the value may change from region to region).
Sewer	A subterranean conduit designed to carry wastewater, sewerage, or waste matter. In some countries (not Australia), the term 'sewer' can include stormwater drainage systems because the drainage systems carry both stormwater and wastewater (e.g. a combined sewer).
Sewer overflow	The discharge of sewage to surface water or to a stormwater drainage system as a result of sewage flow exceeding the sewer capacity (infiltration of rainwater), or as a result of a sewer blockage.
Sheet flow	Flow that passes evenly over the ground as a thin sheet of water as opposed to concentrated flow. Normally occurs on plan surfaces (ground not heavily concaved) and on uniformly grassed areas.
Slab-on-ground construction	A construction method that requires the land to be levelled, usually involving cutting into the slope, to form a flat area of land on which a concrete building slab is laid.
Slaking soil	A soil containing aggregates that collapse in water as a result of the soil having insufficient mechanical strength to withstand the swelling of clay and the expulsion of air from pore spaces. These soils are highly erosive and structurally unstable. It does not include the effects of soil dispersion.

Slot drain	A drainage conduit (enclosed channel), usually recessed below the invert of a shallow open drain, which has an inlet consisting of a slotted grate, or slots cut into the obvert (roof) of the conduit.
Soakage pit	An excavated pit filled with rubble or other open void material into which stormwater is drained for ultimate discharge (infiltration) into the surrounding ground.
Sodic soil	A soil containing sufficient exchangeable sodium to adversely affect soil stability, plant growth and/or land use. Such soils typically have an exchangeable sodium percentage (ESP), expressed as a percentage of cation exchange capacity, in excess of 6 per cent.
Spoon drain	A drain with a semi-circular cross-section with no associated ridge embankment of soil.
Statute law	Law established by legislative enactments.
Stormwater	The run-off of water as a direct consequence of rainfall, whether surface flow, or flow within conduits, including any contaminants collected by the water during its passage.
Subsoil	Sub-surface soil material comprising the B-horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the topsoil.
Swale	A shallow, low-gradient, vegetated drainage channel designed to convey and treat shallow, concentrated stormwater run-off. Vegetation may consist of grasses (grass swale) or herbaceous plants and shrubs (vegetated swale).
Valley floor	An imaginary line that follows the lowest elevation along a valley formed in the land. It is usually the path travelled by concentrated overland flow.
Verge	That portion of the road reserve not covered by the carriageway or footpath.
Watercourse (an 'engineering' definition)	A channel with defined bed and banks, including any gullies and culverts associated with the channel, down which surface water flows on a permanent or semi-permanent basis or at least, under natural conditions, for a substantial time following periods of heavy rainfall within its catchment.
Watercourse (a possible 'legal' definition)	<p>'To constitute such a watercourse, as a matter of law, there must be a stream of water flowing in a defined channel or between something in the nature of banks. The stream may be very small, and need not always run, nor need the banks be clearly or sharply defined. But there must be a course, marked on earth by visible signs, along which water usually flows, in order to constitute a watercourse such as creates riparian rights', Hood J. in <i>Lyons v. Winter</i> (1899) 25 VLR, at p 465 .</p> <p>Such a watercourse may be modified by the actions of humans, such as the cleaning-out of the channel, but such actions must be limited to cases where the work done is of a minor nature. For example, the conversion of a natural drainage swale into a formed drainage channel would not on its own result in the creation of a watercourse.</p>
Watercourse (as recognised by a state government)	<i>(Refer to the definition supplied by the relevant state or territory government; noting that different definitions can be used in different regions of a given state or territory, and different definitions may be adopted within different government departments and within different statutory legislation.)</i>
Waterway	A term commonly interchangeable with the term 'watercourse'. The legal definition may vary from state to state, and region to region.

