

# **A Public Guide to Managing Stormwater Drainage on Residential Properties**



Catchments  
& Creeks

**Version 2, 2020**

# **A Public Guide to Managing Stormwater Drainage on Residential Properties**

Version 2, September 2020

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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 the 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 along a valley floor, or adjacent to a waterway.

The author cannot and does not claim that the document is without error, or that the recommendations are appropriate in all circumstances and for all site conditions.

The author shall not hold any liability or responsibility to the reader with respect to any liability, loss, or damage caused, or alleged to be caused, directly or indirectly, by the adoption of any part of the document to a site specific situation.

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, and 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
- assist the public in understanding many of the issues associated with the design and operation of drainage systems within residential properties
- 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 may apply to the resolution of neighbourhood conflicts relating to stormwater drainage.

This document does **not** provide information on building and drainage codes, nor is the document a substitute for residents seeking their own professional legal advice.

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 photo 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 inferred from the photo caption or the associated discussion that the property or building shown in the photo has been poorly designed, or that the property does in fact experience the drainage problem being discussed. In some cases the photos have been digitally altered to better represent the issue currently 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 40 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

Drainage problems are usually very different from flooding problems. Property flooding can result from a number of sources, including stormwater, but it is most commonly associated with the effects of creek or river flooding. Unlike river flooding, stormwater flooding normally results in just a thin layer of water spilling over floors, but the damage to floor coverings can be just as costly to repair.

Drainage problems can be linked to various building or landscaping issues, including:

- building activities that interfere with groundwater flows
- damaged roofs and roof water drainage systems
- overland flows passing through a property, or
- structures, such as fences, that interfere with the normal passage of stormwater.

Unlike creek or river flooding, most drainage problems can be solved through appropriate building and drainage design. However, not even the best drainage system can prevent some properties from experiencing the effects of creek or river flooding.



Many of the drainage problems experienced on residential properties will be caused by the occurrence of overland flows during major storms. After the severe floods of 2011, the Queensland Floods Commission of Inquiry released a report with 177 recommendations. One of these recommendations was for councils to map all overland flow paths. The fact is, a map of all overland flow paths in Queensland would simply be 'a map of Queensland'.

With the exception of a few sand dunes, there would be no part of Queensland, or in fact the whole of Australia, that would be free of overland flows during major storms. And there is possibly no property in the whole of Australia, even on the highest hills, where a poorly-designed home could not result in the occurrence of drainage problems.

If I were to list the ten most important lessons that I have learnt about stormwater management on residential properties, they would be:

1. One of the best ways to avoid drainage problems on your property is to employ a stormwater professional to check your property drainage. A licensed plumber can design your roof water drainage system, but if you suspect that your property has drainage or flooding problems, then you will likely need the advice of a stormwater (drainage) engineer.
2. Don't assume that by complying with all building and drainage codes that you will automatically avoid all possible drainage problems. Australian building codes have been developed over many years, and by complying with these codes you should avoid most drainage problems, but every property and every building is just a little bit different from every other property and building, and these codes cannot address every possible outcome.
3. Don't assume that it is council's job to prevent you from making a mistake. I have lost count of the number of times home owners have told me that their drainage problems are the responsibility of the local government because:
  - 'they approved our house design'
  - 'they should not have subdivided the land if they knew the land had a drainage problem'
  - 'they should have prevented us from making these mistakes'.

Remember; all properties have the potential to experience drainage problems, and it is not the job of governments to prevent us from making mistakes that are of our own doing.

4. Don't assume that just because your home is above the local flood level, that you will no longer need to think about flooding or drainage issues. The first home I ever owned was located on the top of a hill, well away from the local creek. In the first year I lived in the home the garage flooded as a result of groundwater weeping through the garage walls. Several years later my roof and upper floor level experienced rainwater intrusion as a result of a high-intensity wind storm (The Gap storm of 2008) that had rainwater hitting the side of the house in a near-horizontal direction.

The lesson here is that if a stormwater engineer, that wisely buys the highest house in a street, can experience stormwater and drainage problems, then so can you.

5. Don't assume that all drainage problems can be avoided by installing a 'bigger' drainage pipe. There will always be a bigger storm. All residential properties must allow for the occurrence of major storms, and the resulting occurrence of increased surface flows.
6. Don't believe anyone who tells you that it is unlawful for your neighbour's stormwater to flow into your property. The probability is that the passage of this stormwater is in fact lawful. Which means that it will be your responsibility to appropriately manage the passage of this stormwater through your property (but again, every situation is different).
7. Don't install the type of property fence that will prevent the acceptable movement of stormwater run-off across the land surface.
8. Don't landscape your property such that your stormwater run-off will be directed along a pathway or driveway directly into your home or garage.
9. Don't lower or reshape the road verge (footpath) in front of your home to make it easier for your car to enter your driveway if such modifications will result in stormwater spilling off the road and into your property.
10. And try to ensure that any habitable room that incorporates an outside doorway, has a floor level that is at least 150 mm above the outside ground level, or outside pavers. If you want to reduce this step height, then get expert advice.

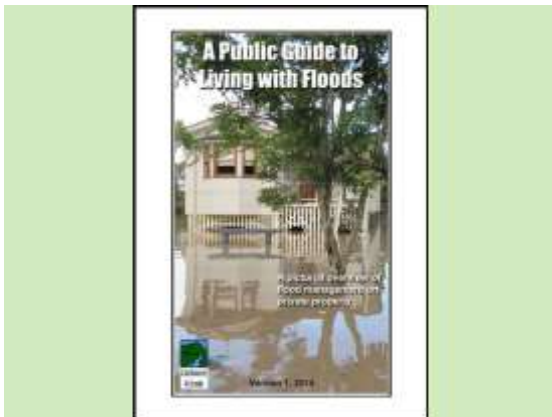
## Introduction



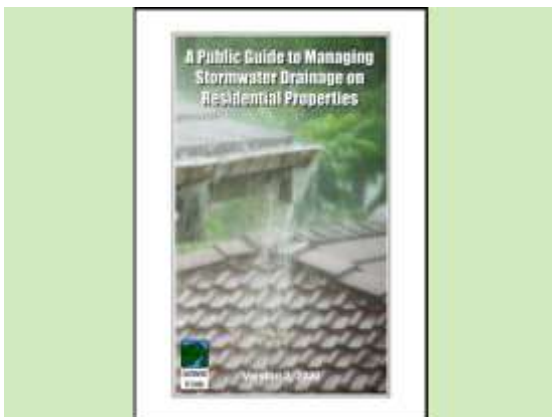
**Roof water drainage**



**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 that soaks into the ground is often referred to as 'groundwater', or sub-surface flows.

### 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
  - stormwater pipes that transport water under the ground
  - open surface drains that transport stormwater over the land.

### Related publication

- The reader's attention is drawn to the related C&C publication (left) that addresses 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 from 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 layout



Property sale



Building construction



Overland flow during a major storm



Court house

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

- Part 1 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 types of buildings and building locations can influence their interaction with stormwater run-off.
- Guidance is also provided on the different types of pre-sale property inspections.

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

- Part 2 provides general guidance on those issues that should be considered when designing or modifying a home.
- General advice is provided on drainage systems associated with low-set (slab-on-ground) homes.
- Readers should refer to Part 3 of this document for more detailed discussion on the design of drainage systems.

### Part 3: Managing stormwater drainage on your property

- Part 3 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 safety issues, and managing stormwater quality.

### Part 5: Rights and obligations of landowners and occupiers

- Part 5 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 seek their own site-specific legal advice if disputes cannot be resolved through informal discussions between all interested parties.



## 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**



**Residential property**

### Collecting information

- Prior to purchasing a home, why not take the time to organise investigations into potential flooding and drainage problems.
- A professional building inspection will likely identify any drainage problems that are currently causing a problem to the building, but may not identify potential future problems.
- A drainage engineer may be required to investigate wider property drainage issues, including flooding.

### Solving drainage problems

It can be confusing to know what role councils play in solving drainage problems.

- If the issue is solely on your property, then it is usually your problem to solve.
- If the issue involves neighbouring private 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, then the council may conduct an investigation to determine who is responsible for any problems.

### 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 managing stormwater on their land:
  - seek-out flood risk information from their local or state government
  - ensure that the property's drainage system complies with relevant building and plumbing codes
  - resolve any drainage problems left unresolved by the previous landowner
  - resolve any drainage problems totally contained within their property.



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

## Natural disasters



**Landslides 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 easy 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



**New residential subdivision**



**Hills and valleys of an urban landscape**



**High-set 'pole' home**



**Low-set 'slab-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 be able to manage the run-off from all storms.



## 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 buildings 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



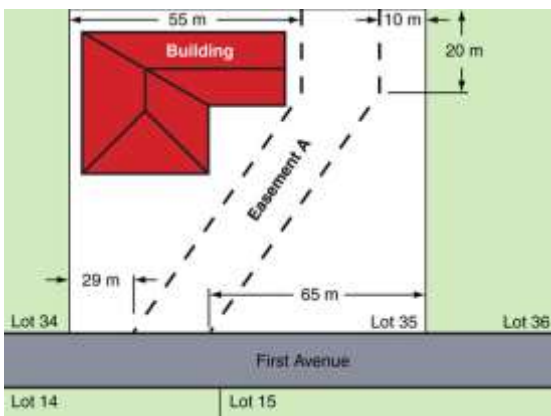
**Property sale**



**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 cause stormwater flooding issues well outside these mapped (blue) areas.
- If such drainage problems occur solely on your 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 at a fence), or when 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 the protection of:
  - underground pipes
  - overland flow paths
  - open stormwater drains.



## Building and property inspections



**Building inspection report**



**Internet search**

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

Continued Next Column

**Yellow Pages (remember these!)**



**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 on 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 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 '*Consulting Engineers*'.

### 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

- A report on the drainage systems of existing buildings is likely to be included in the inspection conducted by the building inspector.
- A plumber can be engaged to further investigate any issues identified within the initial building inspection.
- Specialist roofing contractors can be used to rectify any roofing issues (separate to the roof drainage).



**Waterlogged backyard**

### 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 (landslip)**

### 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 (flood damage)**

### Creek and riverbank erosion

- If a home is located on a steep slope, or close to the banks of a watercourse, then landslips or creek erosion issues could threaten to undermine the building.
- Always ask yourself: *Why is the home up for sale?*
- An 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



**Approaching thunder storm**

### Terminology

- Before discussing the key stormwater issues that may affect your decision to buy a home, it is important to provide an overview of some of the terms commonly used within the stormwater industry.
- Unfortunately the classification of 'minor', 'major' and 'severe' storms can vary from state to state.



**Stormwater inlet for minor storm flows**

### 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.



**Overflowing roof gutter**

### 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 storm flows in Toowoomba, 2011**

### 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 flow capacity of major overland flow paths.
- Typically the probability of these storms occurring in any given year is less than 1% (sometimes referred to as a 100 year or greater storm).
- These are real storms, that can, and have occurred across the country.



## Stormwater drainage



**Medium density urban landscape**



**Overland flow entering a road reserve**



**Stormwater entering a lower property**



**Flooded roadway**

### Introduction

- It is impossible to fully appreciate the drainage conditions on a residential property without understanding how the property interacts with the surrounding landscapes.
- The drainage systems on many properties works in partnership with the adjacent road drainage system.
- For some properties the drainage outcomes will also be directly linked to an adjacent waterway.

### Properties that discharge stormwater into the road reserve

- If the property sits above the adjacent roadway, then the property's drainage system will most likely discharge stormwater to the street.

### Properties that receive stormwater inflows from an adjacent roadway

- If the property lies below the elevation of the road, but not at the bottom of the 'valley', then a raised footpath embankment (the road verge) will often be used to separate the property's drainage from the road drainage.
- If the property lies below the roadway, and is also the lowest property along a given section of roadway, then excess stormwater from the roadway may spill into the property during major storms.

### The hydraulic capacity of road drainage systems

- The piped drainage system that existed under a roadway (if any), is normally only designed to carry the stormwater run-off expected during a minor storm (usually between the 1 in 2 year and 1 in 10 year storms).
- During major storms, the run-off will normally flow over the road surface.
- This means that at some point this excess flow must spill from the roadway into a creek, park, or private property.



## Stormwater drainage



Stormwater flowing towards a valley floor



'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 these properties.
- Controlling overland flows by attempting to 'pipe' all stormwater run-off is not a recommended strategy—there will always be a bigger storm that exceeds the capacity of these pipes.

### Roadside sag inlets

- There are two types of roadside stormwater inlets, *sag inlets* and *on-grade inlets*; however, their visual appearance can vary around Australia.
- Sag inlets typically have a metal grate located in the middle of the kerb opening.
- This type of stormwater inlet normally exists at low points along a roadway.
- 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 drainage 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 such inlet becomes fully blocked with debris—such as litter or garden mulch.

## Stormwater drainage



**Roof water drainage system**



**Overland flow**



**Driveway lowered which allows inflow**



**Installing a new property fence**

### Roof water 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 often occur when people interfere with 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

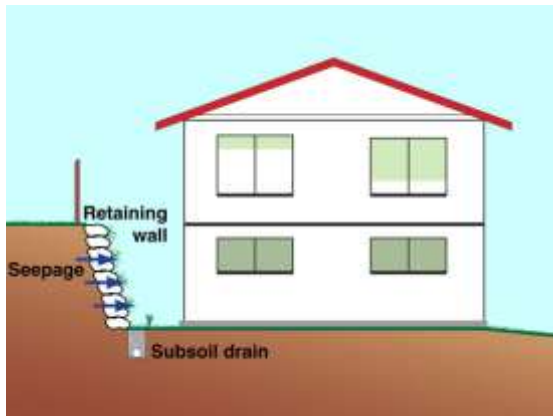
- It is important to study the property fencing and consider its impact on overland flows.
- Historically, property fencing typically consisted of an open style that allowed the free passage of stormwater run-off.
- Renovated properties often install solid fencing (e.g. to enclose a swimming pool).
-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



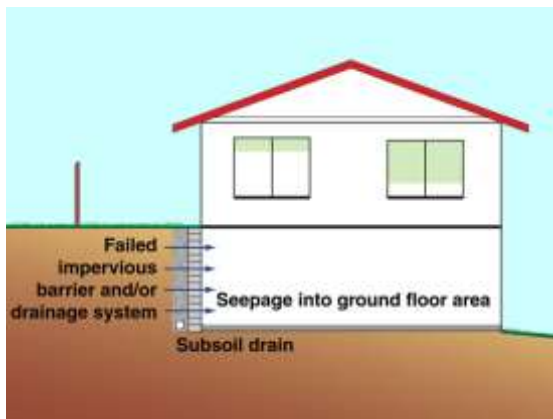
## Stormwater drainage



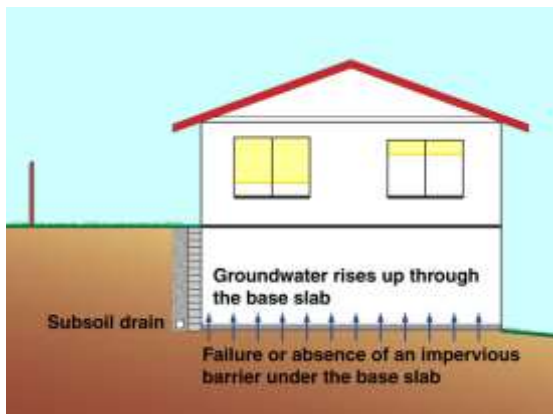
Normal groundwater flow down a slope



Water seeping through a boulder wall



Groundwater seeping through a wall



Up-flow of groundwater through a floor

### Subsoil drainage problems

- Stormwater can pass through a property in three forms:
  - surface run-off (overland flow)
  - piped flow
  - sub-surface flow (groundwater)
- Sub-surface flows exist on all properties, but these flows can cause drainage problems in many circumstances.

### Leaking retaining walls

- The popular usage of slab-on-ground home construction has resulted in the growing need for homes to be built on 'flat' land, which has resulted in a significant use of retaining walls.
- It is normal for many of these walls to 'leak' groundwater during wet weather.
- This water can cause drainage problems if the down-slope land has not been designed to adequately drain away this water.

### Partially buried walls

- If part of a building is recessed into the ground, or earth is placed up against a wall, then during extended periods of wet weather, groundwater can begin to seep through the buried wall.
- This seepage water can pass through cracks in the walls (even cracks that are too small to see with the eye).
- Such drainage problems can be avoided through appropriate wall and subsoil drainage design.

### Groundwater moving up through floors

- Depending on how much of the building has been recessed into the hillside, the groundwater pressure under the building can be sufficient to force water up through cracks or 'cold joints' in the concrete floor.
- This problem is most common when the space under a house was originally designed as an open area, but then converted to habitable rooms.
- Such drainage problems can be avoided through appropriate base slab and subsoil drainage design.



## Stormwater drainage



**Raised fencing over an overland flow path**



**Roadside stormwater inlet**



**Backup of tidal water into coastal suburb**



**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 exist in the event that blockages occur within the piped drainage system, and
  - any new landscaping or fencing placed around a home does not block these essential overland flow paths.

### Solving stormwater issues

- Councils often receive requests from residents to increase the capacity of the drainage system installed along their local roadway.
- In some cases, 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 in some circumstances

- 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 coastal regions, the flow capacity of the piped drainage system may be limited by the backwater effects of high tides, or worse, King Tides.

### 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 a home**

## Design considerations



Building a new home



Site meeting



Home located on highest ground



A choice of building style

### Introduction

- The design of a home requires appropriate consideration of:
  - the building style
  - minimum floor level
  - garage and driveway design
  - roof water drainage
  - design of 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 obtain expert advice from stormwater specialists 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 your 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 placed in the ideal location.

### 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 owner's attention towards 'slab-on-ground' construction, but such construction practices should not be the first choice on steep or flood-prone properties.



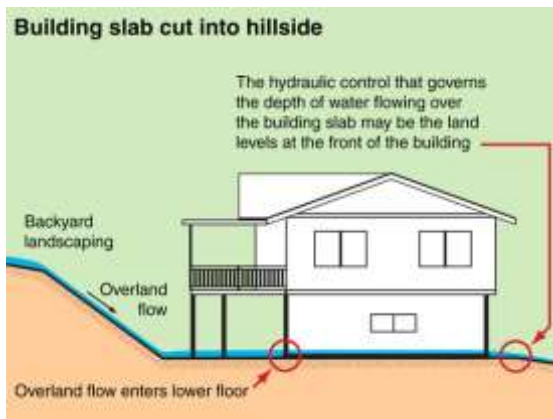
## Choosing a minimum floor level



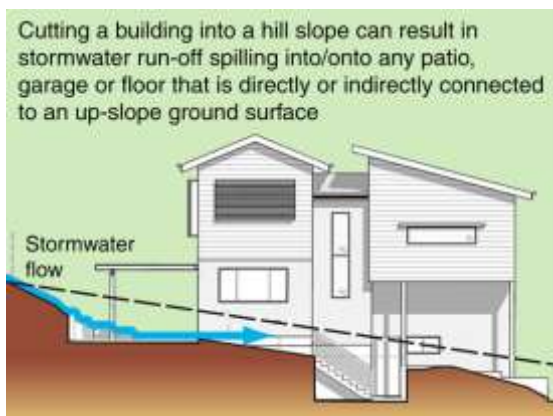
The base slab of a new home



Flood map (Brisbane City Council)



Stormwater flooding of a base slab



Split-level home cut into a hill-slope

### Slab-on-ground construction

- Slab-on-ground construction is the building style most likely to experience flooding and drainage problems.
- Cutting into a hillside to form a flat building platform can initiate drainage problems, all of which will need to be resolved.
- There **must** be a clear flow path for stormwater to move around the building.
- Do **not** make the mistake of thinking that a piped drainage system will be able to carry all stormwater under the building.

### Setting floor levels above flood levels

- Most local governments provide flood maps to help identify flood-prone land.
- Flood maps usually identify only those properties directly affected by creek or river flooding, but some maps also identify storm surge levels and overland flow paths.
- Different councils have different rules on the required minimum floor level relative to flood levels, so the rules may be different from what is presented below.

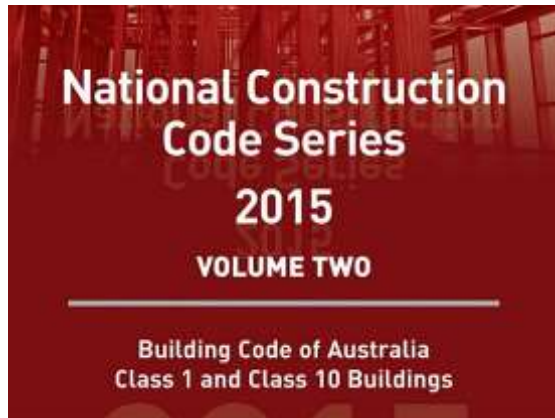
### Slab-on-ground floor levels

- A critical component of a house design is the elevation of the floor or building slab above the surrounding ground.
- Some building codes require floors to be at least 150 mm above the surrounding ground, or just 50 mm above a paved surface that slopes away from the floor slab; however, the latter may not be appropriate in areas of high rainfall.
- **Never set floors flush with any paved, grassed, or earth surface over which stormwater could flow or collect.**

### Assessing the potential for stormwater flooding of elevated floors

- 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 the flooding of elevated floors due to stormwater spilling off any adjoining high 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.

### Construction Code, 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

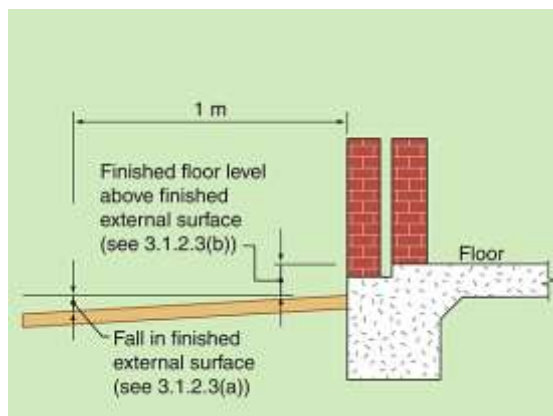


Figure 3.1.2.2

## 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 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 and 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).

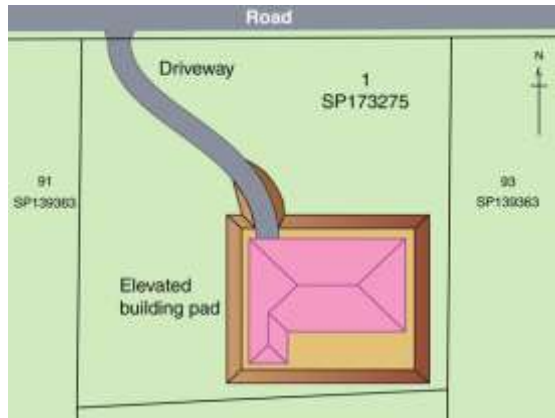
## Circumstances where Section 3.1.2.3 (b) may not be appropriate

- 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.

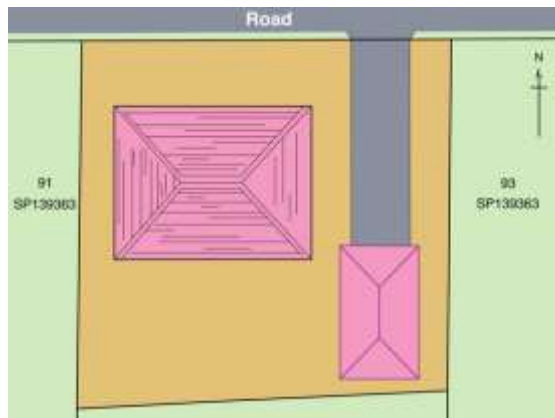
## Required fall of land surface or paving away from the building slab

- 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.

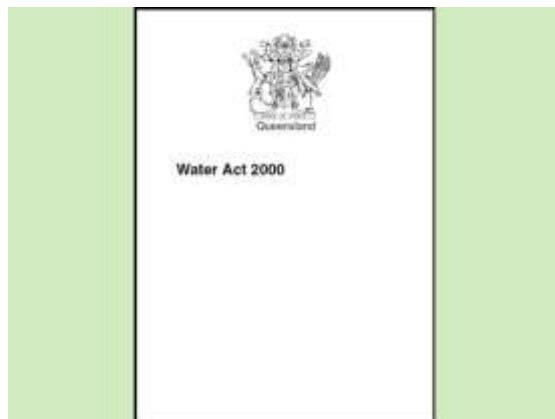
## Raising land levels



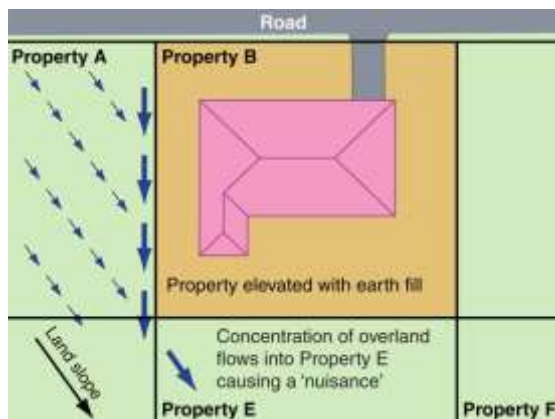
Home built on an elevated platform



Elevating the whole property



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 flood-risk homes 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 whole 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 (see below), and/or
  - a reduction in the flood storage capacity of the floodplain, which can cause an increase in downstream flood levels.

### 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 with your local government before commencing the filling of any 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, and any land filling must not breach the Common Law rights of your neighbours.
- Common Law issues are discussed in more detail at the end of this document.
- The filling of land must not concentrate stormwater run-off onto a neighbouring property, or redirect such run-off onto a property where it would not have otherwise travelled.



## 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 suitably qualified engineer.

## 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 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.
- Retaining walls located close to building foundations should be made from long-lasting materials such as stone.



Crib wall



Concrete block wall



Boulder wall



## Earth retaining walls



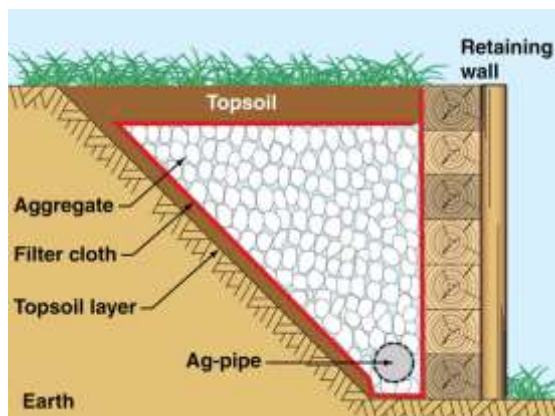
Groundwater seepage from a stone wall



Subsoil drainage pipe (ag-pipe)



Drainage 'blanket' placed against a wall



Subsoil drainage adjacent a clayey soil

### The need for subsoil drainage

- Not all properties will require a formal subsoil drainage system; but most retaining walls and recessed buildings will require additional drainage (see page 20).
- A subsoil drainage system is usually needed in the following circumstances:
  - behind retaining walls to reduce constant water seepage
  - adjacent to any walls that are recessed into the earth
  - 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.
- Standard designs exist for most landscaping work and retaining walls.
- However, this is not a component of your drainage system that you want to get wrong, especially for habitable rooms, so get a professional opinion if you have concerns.

### Two-dimensional drainage 'sheets'

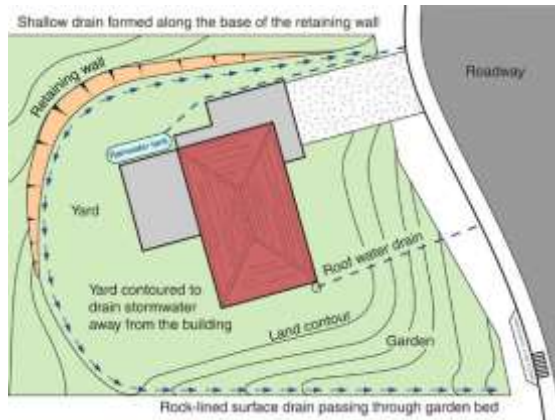
- There is more than one way to design the subsoil drainage system adjacent to a partially buried wall.
- Systems involving gravel beds and traditional 'ag-pipe' can be used, but increasingly designers are using two-dimensional sheet-like drainage blankets that are attached to the buried wall.
- Manufacturers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

### Subsoil drains adjacent sodic soils

- If a subsoil drain is placed adjacent to unstable sodic soil, then the clayey earth can quickly leach into the aggregate causing the adjacent land to slump.
- If such sodic soils exist, then:
  - first cover the earth with a topsoil mix
  - then lay filter cloth over this topsoil
  - then place the first layer of aggregate in the bottom of the trench
  - then install the ag-pipe
  - then finish backfilling with aggregate
  - finally apply the chosen top covering.



## The minor storm drainage system



Property drainage plan



Downpipe 'connected' to the street



Free discharge of roof water drainage



Shallow grassed spoon drain

### Property drainage plans

- The first step to managing the drainage on a residential property is to prepare a drainage plan for the property.
- In most cases this plan can be prepared by your plumber or building designer.
- On sites where significant surface run-off is likely to flow past doorways, the preparation of such a plan may require the assistance of a stormwater or drainage engineer.

### The minor storm drainage system

- **Minor storms** are those frequent storms that have more than a 10% chance of occurring during any given year—these are the storms when an umbrella will actually help to keep you dry.
- Most of the drainage regulations are controlled by national building and drainage codes.
- In general these requirements relate only to the management of minor storm run-off.

### Disconnected roof drainage systems

- Drainage standards can vary from council to council.
- Some councils require the connection of all roof water downpipes to the street, or to a council drainage system.
- Some councils allow certain roof water downpipes to discharge onto lawns and garden beds.
- This 'disconnection' of roof water systems helps to reduce the adverse impacts of urbanisation on local creeks.

### Shallow grassed spoon drains

- Overland flows generated from the wider property are often managed through the use of shallow grassed 'spoon' drains.
- These drains can be used to direct minor run-off away from neighbouring properties and towards the roadway, or another suitable discharge point.
- Raised garden beds can also be used along a fence-line to prevent flows spilling into neighbouring properties.

## The minor storm drainage system



**Drainage outlet to a street**



**Grated stormwater inlet**



**Slot drain with metal grate**



**Soakage drains under construction**

### Piped drainage system

- Most minor storm drainage is managed by piped drainage systems.
- In many council areas it is a requirement that all new roof water downpipes are ultimately connected to a formal drainage system, even though the water may initially discharge into a rainwater tank.
- Some councils do allow stormwater to be released onto grassed areas or garden beds to help reduce the rate of run-off and to help filter the stormwater.

### Grated field (drop) inlets

- Grated stormwater inlets can appear within the yards of residential properties.
- Such inlets are susceptible to debris blockage, especially if they are surrounded by organic garden mulch.
- Given that full debris blockage can occur from time to time at these inlets, it is important to ensure that stormwater run-off can bypass a fully blocked inlet without causing the flooding of adjacent buildings or neighbouring properties.

### Slot drains

- Slot drains are commonly placed on driveways and 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 run-off can pass over these drains.
- The risk of full debris blockage is lower for these drains because of their length; however, a suitable surface bypass is still recommended.

### French drains

- A French drain is a rock-filled drain that allows groundwater to flow along the drain (i.e. through the open voids).
- French drains can be used as a shallow sub-soil drainage system, and to help infiltrate stormwater into the ground.
- The rocks (typically 25 to 100 mm) should be uniform in size with no fines, and with the full drain wrapped in filter cloth.
- French drains should not be used if the soil is dispersive (e.g. a sodic soil).



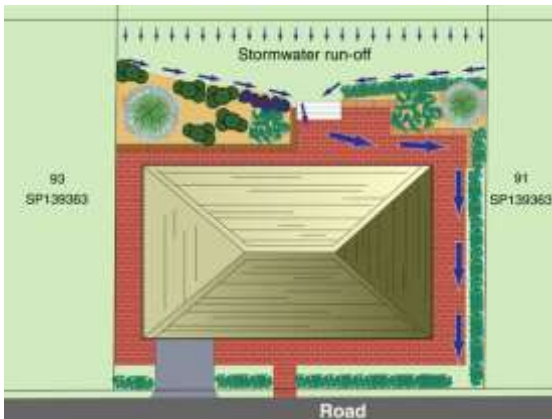
## The major storm drainage system



**Overland flow during a major storm**



**Overland flow**



**Typical property drainage**



**Recessed pathway carrying overland flow**

### Major storm drainage

- The drainage of stormwater run-off from **major storms** is often the forgotten part of a residential drainage system.
- During major storms you often don't get to tell the water where to go; instead, it tells you where it wants to go, and your home needs to allow it to flow past safely!
- Rarely can a piped drainage system handle the run-off generated from these storms; instead, it usually needs to be conveyed over the land surface as '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 of this water, for example, by blocking the flow path with a solid fence.

### Directing overland flows 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 to guide stormwater run-off away from the house.
- This is best achieved by ensuring that any pathway that carries stormwater run-off around the house is recessed below the floor level of the house and garage (refer to page 25).

### Use of pathways as overland flow paths

- Pathways can be a convenient way of carrying surface flows around a house, and possibly carrying this water all the way to the street.
- However, this could mean that you will be walking through fast-flowing water every time you enter your property during wet weather (this can damage expensive shoes).
- If possible, try to direct the stormwater off the path and onto grass as it approaches the front of the house.



## The major storm drainage system



**Backyard landscaping**



**Rock-mulched garden bed**



**Rain garden adjacent to a driveway**



**Recessed driveway & overland flow path**

### Redirecting stormwater run-off

- The passage of stormwater run-off can be redirected using:
  - raised garden beds
  - recessed pathways
  - retaining walls
- An important characteristic 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.

### Drains passing through garden beds

- If surface drains need to pass through garden beds, then these drains should be lined with rocks (e.g. rock mulching) to reduce the risk of organic mulch and soil being washed from your property.
- Grass clippings and organic mulches can cause significant water quality problems if they are allowed to wash into creeks.
- Certain 'mat-forming' groundcover plants can also be very effective in these areas of high surface flow.

### Using driveways to carry overland flow

- In new homes, driveways are often used to carry stormwater run-off to the street, a rain garden, or a stormwater detention system.
- 'Rain gardens' are special recessed garden beds designed to temporarily pool, then filter, stormwater run-off.
- Stormwater detention systems are used to attenuate the discharge of stormwater from a property in order to reduce the risk of overloading the downstream drainage network.

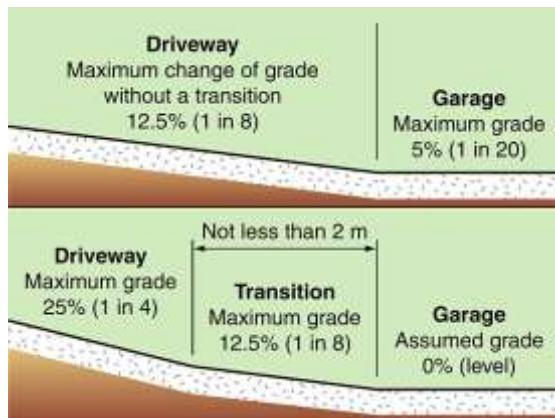
### Recessed driveways

- 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 an alternative location if a severe storm warning is issued.
- A separate pedestrian pathway must exist in order to allow people to safely enter the property during major storm events.

## Driveways and garages



**Driveway with slot-drain drainage system**



**Change of gradient on steep driveways**



**Water spilling from a road into a driveway**



**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 is 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

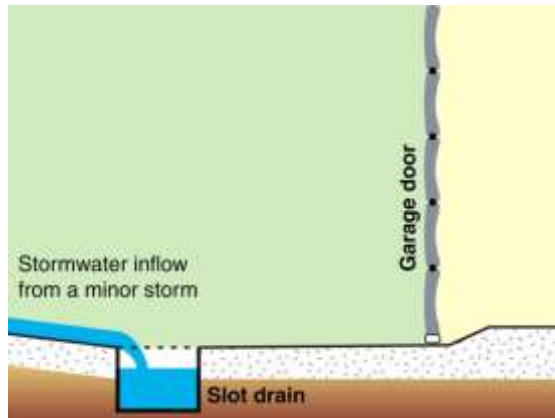
- Consider the potential for stormwater run-off to enter the driveway from the following sources:
  - excess stormwater flowing along the street that may spill into your driveway (even if your driveway is not located at a low point along a roadway)
  - stormwater spilling into your driveway because it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

### Use of slot drains

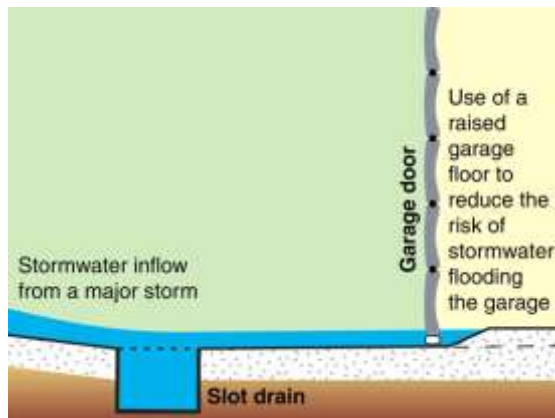
- Slot drains are commonly placed in front of garages to capture and redirect stormwater run-off.
- Typically these slot drains only capture the run-off from minor storms.
- During major storms, stormwater may pass over these drains.
- Caution; the metal grates placed over these drains may need to be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



## Driveways and garages



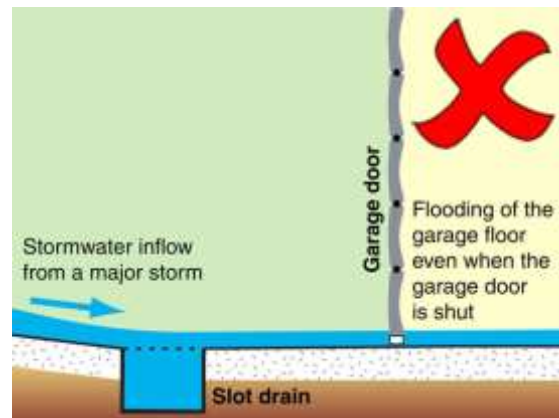
Stormwater inflow during a minor storm



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.



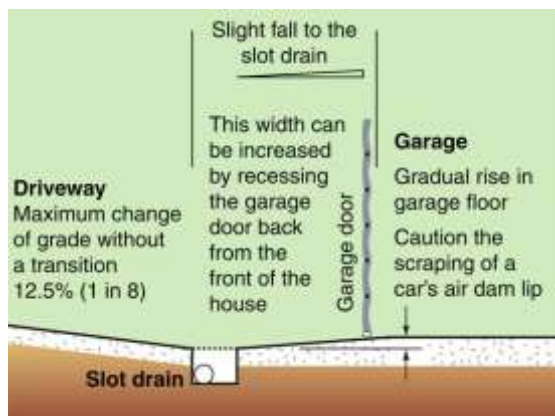
Potential flooding of low-level garage



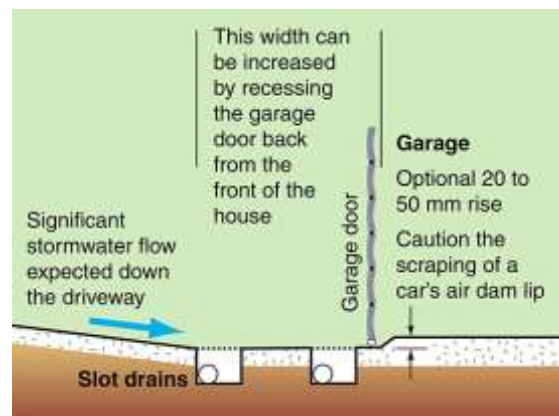
Slot drain located too close to the garage

### 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 placing additional slot drains at regular intervals along the driveway.



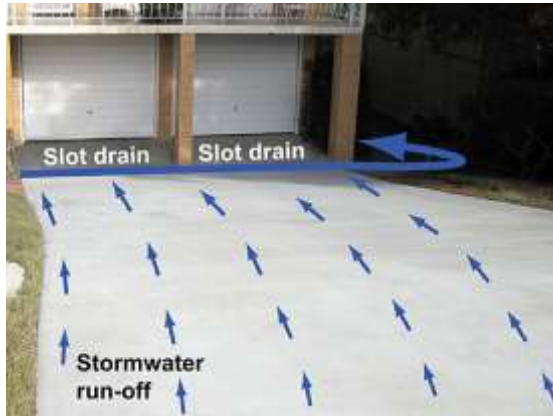
Single drain with gradually elevated floor



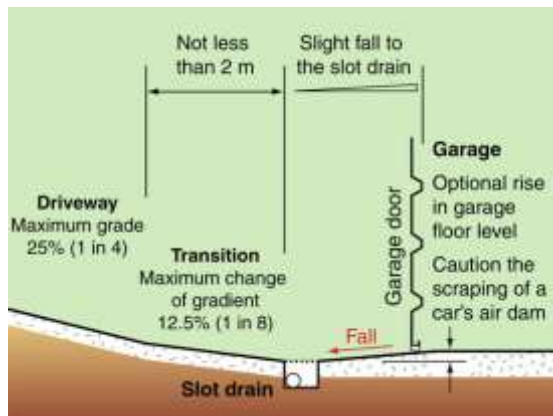
Double drain with elevated floor 'step'



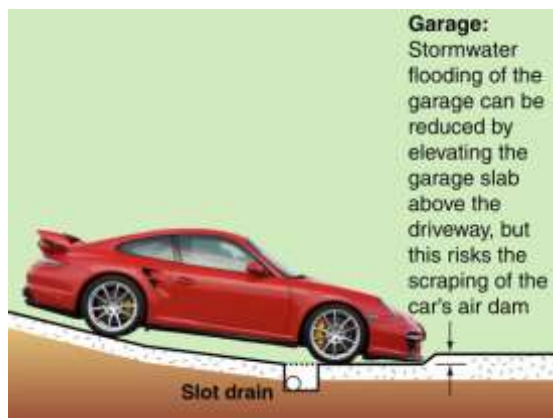
## Driveways and garages



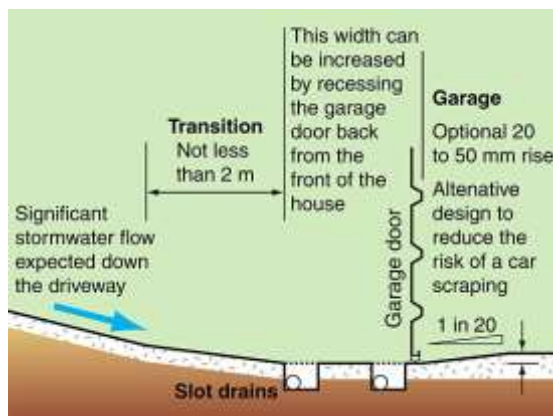
Slot drain located away from the garage



Steep driveway with gradual rise in floor



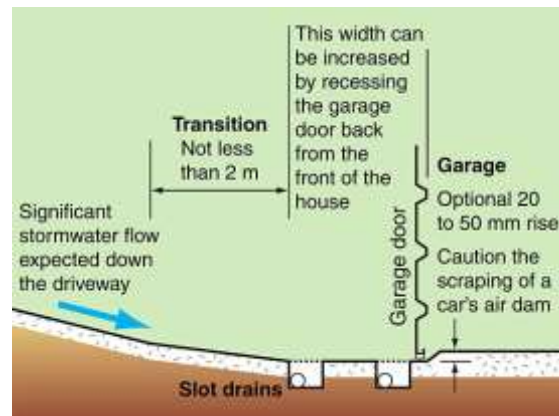
Potential problem of an elevated floor



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 the garage.



Double slot drain with raised floor

### Checking that the driveway profile is 'car friendly'

- Elevating the garage floor can significantly reduce the frequency of stormwater flooding 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.

### An alternative design of 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 (also ensuring that a trip hazard is avoided).

## Roofs and roof water drainage systems



Roofing styles



175 mm wide roof gutter



External, saddle-type bracket



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 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.



## Rainwater tanks



Rainwater tank



Downpipe leaf filter



Twin (yellow) pressure tanks



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 (e.g. toilet flushing)
  - reducing erosion problems within urban waterways caused by increasing urbanisation
  - 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 a 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.



## Stormwater detention systems



A rain garden detention system



Detention tank installed under driveway



Stormwater detention using a 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 residential, 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 town planning rules or 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.

## Stormwater quality systems



Oil pollution of stormwater run-off



Discharge onto a garden bed



Roof water soakage pit



Residential rain garden

### Introduction

- For most people it will be the **quantity** of stormwater run-off that causes them drainage problems.
- For some people, and for downstream aquatic environments, it will be the **quality** of the water that is of most concern.
- Many of our homes help in the collective generation of electricity through our use of solar panels, similarly we should all do our bit to help in the 'cleaning' of our stormwater run-off.

### Discharging roof water onto garden beds and grassed surfaces

- In urban areas, roof water run-off can be contaminated with:
  - airborne pollutants
  - possum and bird faeces
  - metals washed from metal roofs.
- Discharging roof water onto grassed areas can help to filter many pollutants.
- Caution; some councils will require all new roof water systems to be connected to a formal drainage network.

### Infiltration systems

- Many forms of mandatory stormwater detention systems do not contribute to improving the quality of our run-off.
- When designing a new home, the focus should be on installing a drainage system that achieves multiple outcomes, including detention, treatment and reuse.
- Infiltration systems, such as soakage pits, sand filters and porous pavements, can achieve both stormwater detention and treatment.

### Rain gardens

- Rain gardens can be used for stormwater detention and plant-based treatment (known as 'bio-retention').
- These gardens can collect run-off from both minor and major storms, in residential properties, roadside verges, and parks.
- The science behind rain gardens is heavily researched, and detailed design guidelines have been prepared by all states.



## Property fencing



**Wire mesh fencing**

### Stormwater and drainage considerations

- As a general rule, stormwater run-off occurs naturally over all land surfaces, except for some beaches and sand dunes.
- This means most property fences need to allow some degree of through-flow, otherwise the fence will potentially cause the unlawful redirection of the stormwater run-off onto someone else's property.
- There are many different styles of property fencing that facilitate the 'acceptable' movement of stormwater run-off.



**Pool safety fencing**



**Open picket fence**



**Timber fence with well-spaced palings**



**Elevated metal panel fencing**



**Vegetative hedge 'fencing'**



**Minimal boundary fencing**



## Property fencing



Overland flow along a drainage reserve

### 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 valleys where stormwater run-off concentrates on its passage 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

### Fences that incorporate animal control features

- The design of a property fence can become very complicated if part 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



## Property fencing



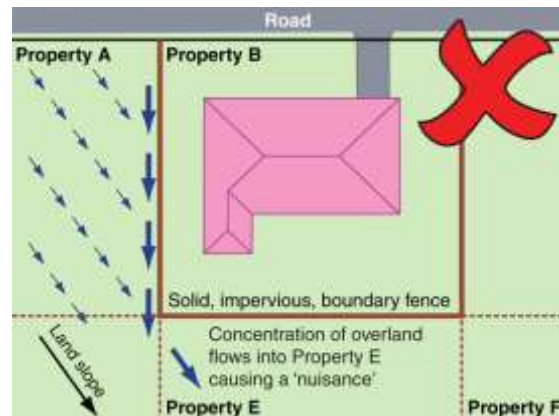
**Solid, impervious timber fencing**

### 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 linked to the approval of an urban development.
- Before installing any such fencing, home owners 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**



**Flood damage to a timber fence**

### 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 debris blockage of mesh fence**



**Flood debris damage to a steel fence**

## **Part 3: Solving drainage problems**



## Introduction



Approaching thunder storm



Overland flow during a major storm



Overland flow during a major storm



Stormwater discharged 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 include problems associated with:
  - stormwater flows entering or leaving your property
  - stormwater flows that pass through your property
  - groundwater seepage
  - stormwater quality issues.

## 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 fact 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 any stormwater issues that concern you.

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

- In many cases, drainage problems only become obvious during major storms, often 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 passing 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 overland flow 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 unreasonably concentrated.

## Where to get help



Roof water run-off during a major storm



Overland flow path



Landscaping a backyard



Gully erosion

### Roof water drainage

- The following is a simplistic generalisation of the roles of different stormwater and drainage professionals.
- In all cases, what matters most is the training and experience of the individual professional.
- If your drainage problems have anything to do with the roof, gutters, or buried pipes, then you are best to approach a plumber for advice.

### Major storm drainage

- If your drainage problems primarily occur during those infrequent major storms, then you are best to approach a drainage or stormwater engineer for advice.
- The terms 'drainage engineer' and 'stormwater engineer' are generally interchangeable.
- What makes an 'engineer' different from a 'plumber' is the engineer's knowledge of how flow conditions can change as the water moves from subcritical flow conditions to supercritical flow.

### Property landscaping

- If you believe that your drainage problems can be solved by re-landscaping your property, then:
  - in most cases your plumber could coordinate with a landscape contractor
  - if serious floor level flooding is occurring, then seek the advice of a drainage engineer.
- On complex sites, seek the advice of a [landscape architect](#) in preference to the general advice of a landscape contractor.

### Severe soil erosion or gully erosion problems

- If overland flows through your property are causing gully erosion, then approach the council, Natural Resource Management group, or Landcare office for the names of local specialists.
- If your earth retaining wall is shifting then seek the advice of a geotechnical engineer.
- If you have sodic, dispersive, slaking, or acid sulfate soils, then seek the advice of a soil scientist.



## Problems caused by stormwater entering or leaving your property



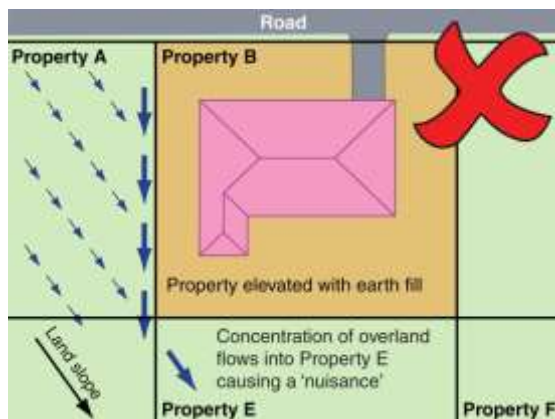
**Stormwater inflow into a property**



**Overland flow during a major storm**



**Combined drainage reserve and pathway**



**Potentially unlawful diversion of run-off**

### Lawful inflow of stormwater

The lawful nature of stormwater inflows into 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 public 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.

### Common law issues

- In most circumstances, if a person takes actions that cause harm to another person, then the first person can be held liable for any damages.
- However, in the case of stormwater run-off, the legal rights of each person can be very complicated, and it is not always a simple case of preventing 'nuisance'.
- The rules are not simple to understand, and readers are advised to seek their own legal advice.

## Problems caused by stormwater entering or leaving your property



**Council park up-slope of urban properties**

### 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 no more legal obligation to divert stormwater away from your property than any other landowner.
- In practice, most councils try to confine concentrated stormwater flows to road reserves, drainage reserves, and drainage easements.



**Major storm discharge from a roadway**

### 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 the road was constructed.



**Stop and think!**

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

- Part 5 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 the property contains an easement or the like).
- In other words, you cannot simply divert your problem towards someone else.



**Solid fence blocking overland flows**

### The potential impact of property fencing

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



## Problems caused by stormwater entering or leaving your property



**Stormwater 'kerb' outlet to a roadway**

### 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.

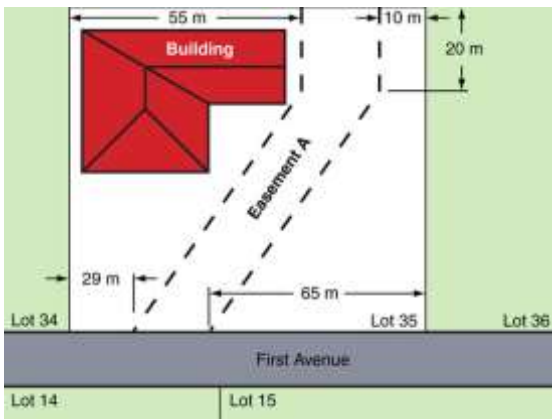


**Stormwater erosion under a fence**

### 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.



**Drainage easement**

### Discharging onto a drainage easement

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

- such increases are consistent with the specific 'rules' 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.



**Landslip caused by stormwater discharges**

### 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.

## Problems resulting from properties being located down-slope of roads



Home located down-slope of a roadway

### Properties down-slope of roads

- In general, the probability of experiencing a drainage problem on a particular property is not related to whether a property sits above or below the adjacent roadway, but more critically on how stormwater is managed through the property.
- For properties located down-slope of a roadway, the driveway can become a major flow path for stormwater run-off, and this run-off normally aims directly at the house.



Stormwater passing down a roadway

### Roads are designed to carry stormwater

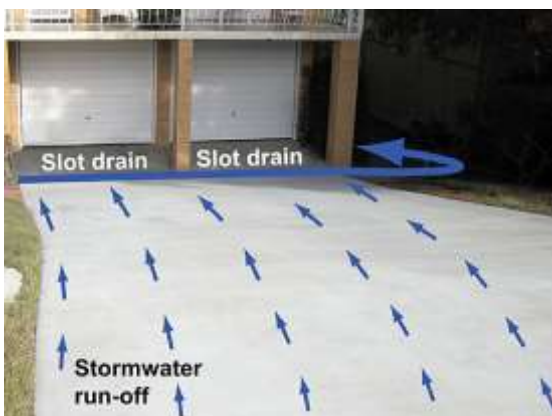
- Most roads are designed to carry stormwater run-off during storm events.
- The pipes that pass under roads are only designed to carry the stormwater run-off that results from 'minor' storms; those being the more frequent storms.
- The occurrence of stormwater passing down a roadway does not necessarily mean that the road drainage is under-sized, or that the drainage engineers have made a mistake, it could just mean that there was a lot of rain!



Driveway lowered below the footpath level

### Modifying your driveway entrance

- If a property is located below the roadway, then residents need to consider the risk of flows passing from the roadway into the 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.



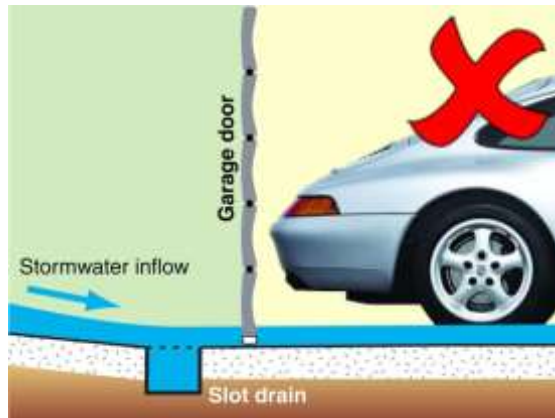
Stormwater diverted away from garage

### Drainage up-slope of your garage

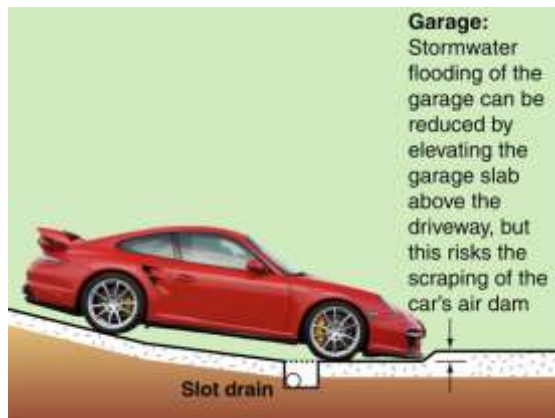
- The most common drainage problems experienced on properties that sit below a roadway are those associated with the garage and driveway.
- The garage floor should be higher than the driveway located directly in front of the garage door—a slot drain or similar can be placed along this low point to direct stormwater away from the garage.
- Discussion on the design of driveway drainage systems is provided in Part 2 of this document.



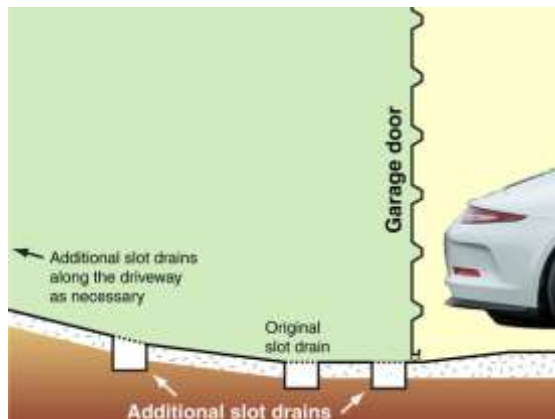
## Diverting stormwater away from your garage



Stormwater flooding of a garage



Potential problem of an elevated floor



Installation of additional slot drains



Flow diversion strips set in a driveway

### Solving garage flooding problems

- If a 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 flows away from the driveway
  - diverting stormwater off the driveway at intermediate points along the driveway.

### Raising the garage floor height

- 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 scrape on the garage floor when entering or leaving the garage.
- Further discussion on designing driveways and garage floor is provided in Part 2.

### 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 reaching 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



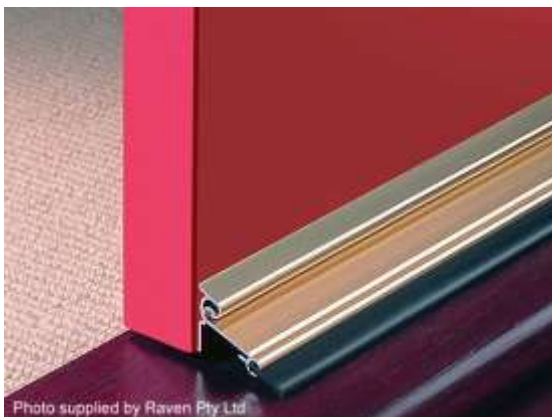
**Flood-prone doorway**



**Diversion of stormwater**



**Slot drain placed in front of doorway**



**Automatic water seal installed on a door**

### Stormwater entering doorways

- Homes located on any type of sloping land can experience stormwater flooding problems if doorways are not appropriately elevated above the adjacent ground.
- Ideally, affected floor levels should be at least 150 mm above the outside ground level or paved surface.
- If you want to reduce this step height, then get expert advice—a 50 mm height difference may be lawful, but may not be wise in all circumstances.

### Diversion of water away from a doorway

- Stormwater flooding of doorways is possibly more common than river flooding of homes.
- Corrective measures can include:
  - redesigning the property's landscaping to direct stormwater away from the doorway
  - lowering and reshaping the land in front of the doorway
  - installing a drainage system (slot drain) in front of the doorway.

### Installation of a drainage system

- The drainage system may consist of a slot drain; however, these drains can look unattractive, and may present a safety hazard to people wearing high heel shoes.
- Alternatively, a complex drainage system may consist of paving stones glued to the surface of an extensive drainage system (slot drains or the like) with small gaps left between each paving stone to allow the inflow of stormwater (i.e. porous paving).
- Such a paving setup is unconventional, and paving contractors may not be familiar with such a drainage system.

### Water seal 'flap' installed on the door

- If the stormwater intrusion under the doorway is a minor issue, then various commercial products exist that can be attached to the base of the door to reduce the inflow of rain or stormwater.



## 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 positioned in the event of a severe storm or flood warning.
- Similar systems can be installed on recessed driveways to protect garages from minor flooding and storm surges.



Watertight flood gate



Flood Angel Flood Defender



Stormguard Floodplan Flood Defences



Image Flood Defence



Floodgate



Hydrosshield

## Case study: Preventing stormwater intrusion into a house



**Low-set doorway subject to flooding**

### The problem

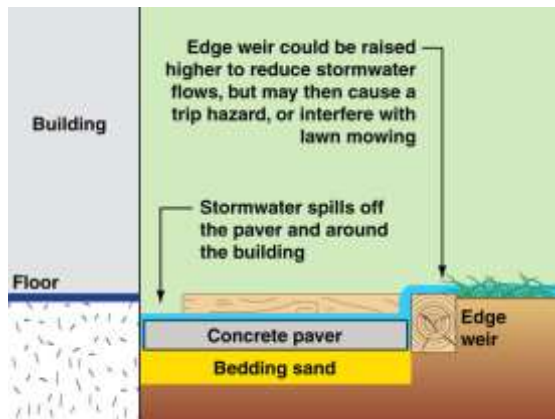
- The following is an example of an actual drainage problem at the back door of a two-storey residential property that has been recessed into the hill slope.
- New landscaping of the backyard resulted in land levels being raised to the height of the back doorway.
- During subsequent storms, stormwater 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.



**Modified doorway entrance**

### The solution

- The key to solving this drainage problem is to re-contour the immediate area in a manner that encourages stormwater to move away from the doorway and around the building.
- During severe storms, stormwater can elevate 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.



**Flow passage under and around building**

### 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 timber weir allows stormwater to pass around 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.



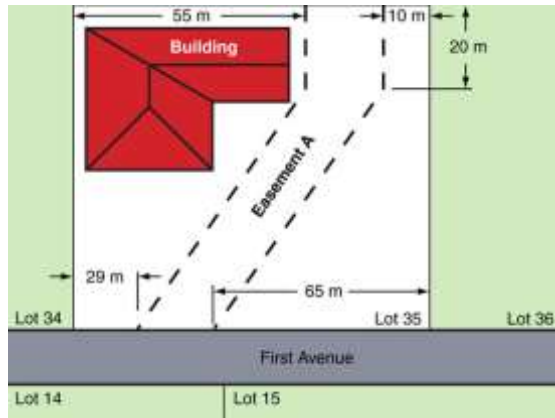
**Revised stormwater flow path**

### Encouraging water to flow around the building

- The land has been lowered along the side of the building to form a gravelled overland flow path (not visible in photo).
- At the edge of the building a new set of paved stairs has been constructed that will encourage some of the approaching stormwater to flow around the building instead of past the doorway.
- This example represents a specific solution to a specific set of site conditions.



## Managing overland flows and drainage easements



**Drainage easement**



**Drainage easement used as a driveway**



**Mulch displaced by stormwater**



**Overland flow path passing under building**

### Drainage easements on private property

- Drainage easements exist for the purpose of protecting the operations of overland flow paths and/or underground pipes.
- The existence of a drainage easement allows authorities to ensure that:
  - structures are not built within the easement in a manner that may interfere with the flow of stormwater
  - the easement is maintained by the landowner so as not to cause a nuisance to adjacent properties.

### Protection of personal items

- The existence of a drainage easement on a property does not prevent the landowner from using the land for other purposes such as a driveway, pathway or lawn.
- Loose materials such as garbage, lawn clippings, or sand/soil stockpiles, should not be stored within an overland flow easement.
- The easement must be maintained such that authorities have access to the easement to conduct inspections and carry out necessary maintenance.

### Placement of garden beds

- Landowners must manage the land contained within an overland flow easement in such a manner that does not adversely affect neighbouring properties and receiving waters.
- If garden beds are established, then rock mulching should be used across flow paths instead of organic mulch.
- Any mulch or debris blockages that occur along the easement must be cleared away after storm events.

### Easements passing under buildings

- In most cases it is not advisable for buildings to be constructed over drainage easements, or overland flow paths.
- However, if appropriately designed, industrial developments can sometimes make effective use of the land-space above a drainage easement.
- Landowners should never attempt to fully pipe the stormwater flows passing through their property as a means of removing the need for an overland flow easement.

## Managing groundwater seepage problems



Seepage from a boulder wall



Salt damage from rising groundwater



Subsoil drainage behind a retaining wall



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, and/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 that a subsoil drainage problem exists—if the marks appear on brickwork, then the problem may be more complex.

### Subsoil drainage systems

- Different types of subsoil drainage systems exist including agricultural drainage pipe (ag-pipe) and high-flow plastic drainage 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, mould and timber rot.
- 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.



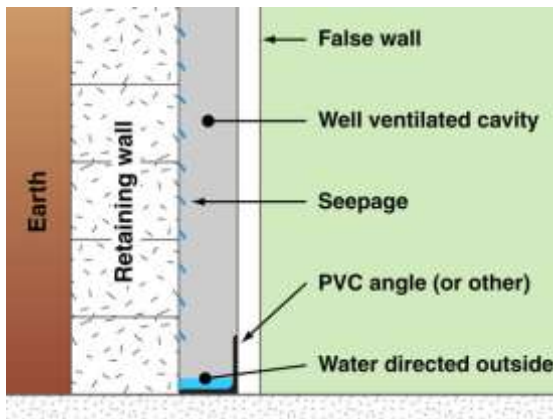
## Managing water seepage through walls



Earth being removed from rear of house



Injection of waterproofing sealer



Draining of water behind a false wall



Commercial baseboard drain (USA)

### Introduction

- If a building experiences groundwater seepage problems through partially buried walls, then there are three possible solutions:
  - remove the earth from the outside of the wall (left)
  - make the wall waterproof in order to stop all leaks
  - allow the seepage to continue, and use a floor drain to direct any seepage water out of the building.

### Waterproofing walls and floors

- Various injection waterproofing systems are commercially available, using either:
  - epoxy liquids if high strength is required along with the waterproofing, or
  - polyurethane foams if the waterproofing needs to find its way into micro-cracks.
- These processes can never be 100% successful 100% of the time—it only takes one crack to be left untreated in order for the seepage problems to continue, but the process can still be worth trying.

### False walls (not an ideal solution)

- Installing a false wall can 'hide' the drainage problem, but:
  - the wall cavity will need to be well ventilated, and
  - a water-tight floor drain will be required to capture any seepage water, and to channel this water out of the house, and
  - the discharge channel needs to be appropriately screened to prevent the intrusion of vermin.

### Baseboard drains

- Various commercial baseboard drains are available that can be used to capture seepage water and carry this water out of the house.
- These solutions do not solve the drainage problem, they simply alter the consequences in a manner that should allow the continued operation of the room or garage.

## Case study: Correcting a groundwater seepage problem



**Earth fill placed against lower walls**

### Home with earth placed against the lower walls

- This is a high-set house that has had the original open breezeway under the home enclosed to form additional habitable rooms under the main living floor.
- Earth was then placed up against the lower walls in order to form a level backyard.
- During extended periods of wet weather, groundwater would seep from the earth, through the cladding, and then into the lower floor.



**Earth removed from the rear of house**

### Bulk earth removal from the property

- Bulk earth was removed from the side of the building to fully expose all walls.
- 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 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.



**Incomplete 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.
- 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.



## Stormwater quality problems



**Contaminated stormwater discharge**



**House paint washed into street kerb**



**Roof and house washing**



**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 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 creek.
- Wash your car on grass and allow the excess water to benefit your lawn rather than being discharged to the street.

## Stormwater quality problems



**Grass clippings dumped over a fence**



**Pointless personal pollution!**



**Washing down a roadway**



**Topsoil placed on a roadway**

### 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.

### 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.

### 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.

### 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.



## General problem solving

Finally, I would like to point out that when it comes to solving drainage problems, it is important to reflect on the idea that there are usually [four types of solutions](#) that can be explored when looking for ways to manage any problem, these solutions are:

- (i) remove yourself from the problem
- (ii) remove the problem from yourself
- (iii) change the outcome of the problem
- (iv) change your response to the problem.

These problem solving options can be universal in their application, for example, if you find yourself being confronted by a neighbour in regards to your stormwater, then your options are:

1. Walk away and deal with the problem once your neighbour calms down.
2. Ask your neighbour to leave your property.
3. Try to explain to your neighbour the common law issues in relation to stormwater run-off, or suggest to your neighbour that they could seek the advice of a stormwater professional.
4. Accept your neighbour's comments and look for ways you can reduce your neighbour's drainage problems, even if there is no legal obligation for you to do so.

The same method of problem solving can be applied to the management of drainage problems. For example, if groundwater is seeping through a basement wall, then your options may be:

1. Sell the home, or to stop using the basement to store equipment.
2. Remove the earth from the side of the building, or excavate the earth and reconstruct a better subsoil drainage system next to the wall, and/or excavate the earth and apply an impervious seal to the wall, or use injection waterproofing to seal the leaks in the wall.
3. Install a baseboard drain at the base of the wall to collect any water and carry it out of the house, or build a false wall that hides the problem (which would also incorporate a floor drain to carry the water out of the house).
4. Elevate any equipment stored in the basement so that it is not affected by the occasional movement of water over the floor, or install a false floor that achieves the same outcome.

Similarly, if stormwater was spilling from an adjacent roadway into your driveway during major storms, and this water was subsequently entering your home or garage, then your options may be:

1. Sell the home, or relocate the garage.
2. Have the road authority investigate if the road's drainage system is operating correctly, or investigate if you or a previous owner of the property had modified (i.e. lowered) the driveway entrance in a manner that was causing stormwater to spill from the roadway.
3. Modify the contours of the driveway to cause any stormwater run-off to be deflected away from the house or garage, or install additional drains in the driveway to redirect the stormwater around the house or garage, or modify the floor of the garage to prevent the stormwater from entering the garage.
4. Remove any potentially water-damaged goods from the garage, and accept that the occasional flooding of the garage will not adversely affect either the car or the garage.

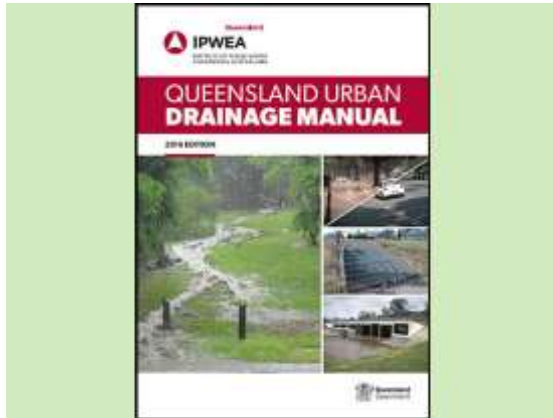
The outcomes may not always be realistic, but it is important to remember that the aim of such a problem solving process is to encourage [lateral thinking](#). To force people to think of solutions that may not at first appear obvious, but eventually can turn into a solution that not only solves the problem, but also saves you money. In each case, try to picture in your head the movement of stormwater through your property.

In extreme cases your solution may be so original, and so inspiring, that you spend the next decade boring your family and friends with an endless description of your drainage problems and your subsequent ingenious solutions.

## **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.
- During major storms these systems can overflow causing flows down roadways.

### Major storm drainage systems

- Residential areas are most commonly designed with roadways passing along the valley floor so that they can carry the run-off from major storms without causing property flooding.
- If you observe significant quantities of 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 storm events.
- It is not unusual for an urban creek to widen and deepen to a channel size that is twice the size of the original creek.



**Fish kill in an urban waterway**

### Loss of aquatic wildlife

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



**Sediment-laden stormwater run-off**

### Water quality impacts

- Aquatic life within urban waterways is also adversely impacted 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.).



## Minimising impacts on natural waterways



Urban waterway

### Typical 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.



Stormwater retention basin

### Typical steps taken by councils to reduce 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.



Multi-function waterway culvert

### Typical 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 existing, non fish-friendly waterway structures.



Urban stormwater treatment wetland

### Typical 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 systems
  - vegetated sand filters
  - grass and garden filters placed adjacent to impervious surfaces such as roadways and car parks
  - wetlands and water treatment ponds.

## Minimising impacts on natural waterways



**'Dump No Waste – Flows To Creek'**



**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.

### 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 some pipes—this material is not harmful, 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 and containers is critical on and around coastal waters where such items 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 can 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.

## Regional stormwater treatment systems



**Local street rain garden**



**Bio-retention system**

### Roadside stormwater treatment systems

- This page presents examples of roadside stormwater treatment systems.
- Roads can be a major source of harmful pollutants originating from the engine, fuel tank, brakes and tyres of motor vehicles.
- Even lead-free petrol is a source of harmful pollutants.
- Most of the really harmful pollutants are 'particulate' in nature, which means the pollutants can be filtered by passing the stormwater through soil or sand filters.



**Bio-retention system**



**Bio-retention system**



**Stormwater treatment ponds**



**Bio-filtration system**



**Gravel infiltration trench**



## 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 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.

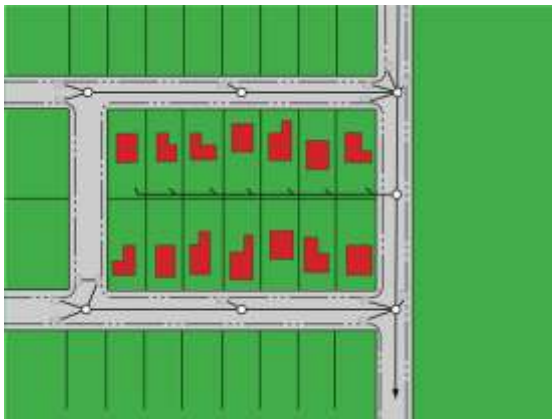
### Resolving disputes

- 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 modifications to existing buildings.

### 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 differ 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 council is more 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 approved, 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

**Old roof water 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/NZS 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 and 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.
- As discussed above, many councils refer to the stormwater drainage requirements contained within AS/NZS 3500.3.

### Drainage from old buildings

- The drainage regulations applicable to existing buildings are those that existed at the time of the building's approval.
- This means that some older buildings may lawfully have drainage systems that do not comply with current building codes.
- If this drainage system is found to be causing a nuisance to a neighbouring property, then it can be a very complex legal issue as to whether or not the drainage must be modified, but we are all encouraged to be a good neighbour.

### Drainage from home extensions

- Stormwater drainage on a 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.
- Downpipes may be connected to a rainwater tank, but the tank's overflow must connect to a recognised drainage network.

## The application of 'common law' rights in drainage disputes



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.



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.



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 over the following pages.



Flows caused by a water pipe failure

### Application of the common law principles

- The following common law principles relate only to surface waters that come 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 burst 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 a legal professional.



## 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 of the 'normal use of the land', and this flow concentration is no more than is considered reasonable in order to achieve the 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.
- Drainage complaints between neighbouring properties can be very complex legal issues to resolve. Sometimes the resolution will favour the up-slope property, and sometimes it will favour the down-slope property.

## 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, if several up-slope properties were 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 subdivision 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 subdivision 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

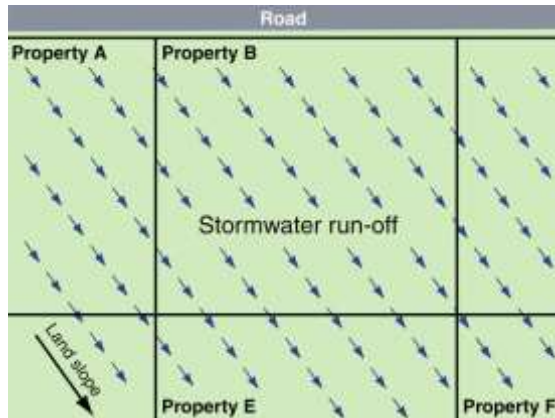
- It may be added that the proprietor's right to defend their land against water coming upon it by erecting barriers, is generally speaking restricted to penning it back on to the higher land whence it would otherwise have naturally come.
- It does not entitle them to divert it on to the land of a third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

### This means:

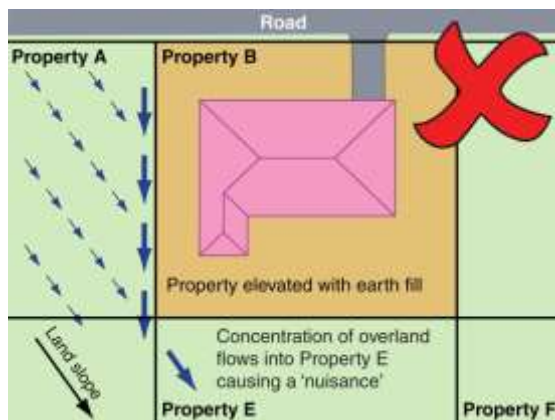
- This final principle is very important in an urban context because stormwater run-off often flows naturally, in a diagonal alignment, across several residential properties, and as a result, can cause disputes between the numerous property owners.
- The owner or occupier of a down-slope property can 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



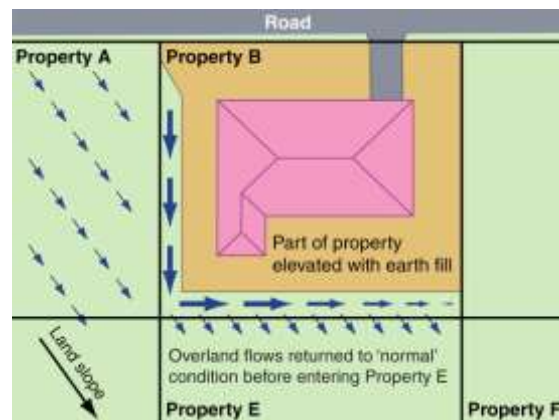
Case 1: Flow conditions prior to land filling



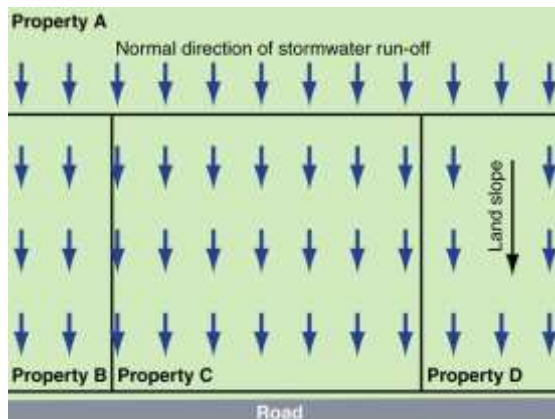
Potentially unlawful diversion of run-off

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

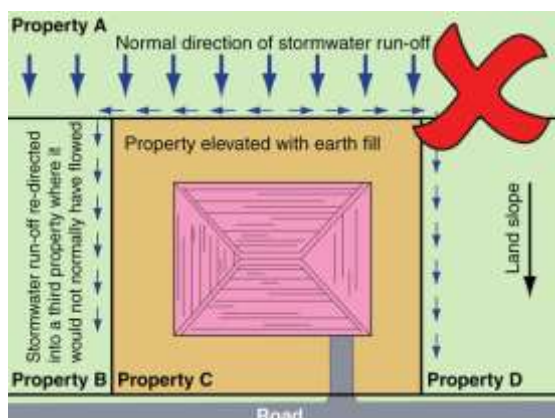
- In the long-term, land filling can provide lasting benefits to the community by permanently removing homes from a potential flood risk.
- However, it is important to make sure that the filling of one property does not result in the redirection of stormwater run-off in a manner that causes a nuisance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



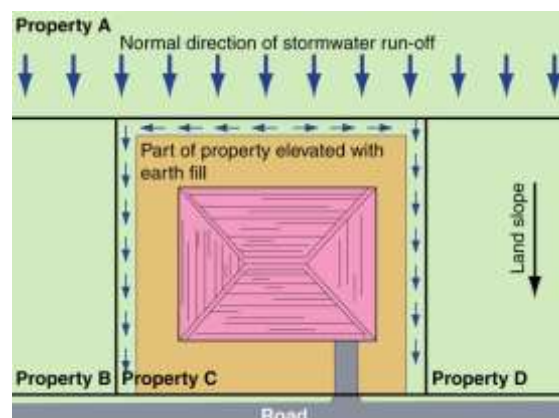
Possible lawful use of land filling



Case 2: Flow conditions prior to land filling

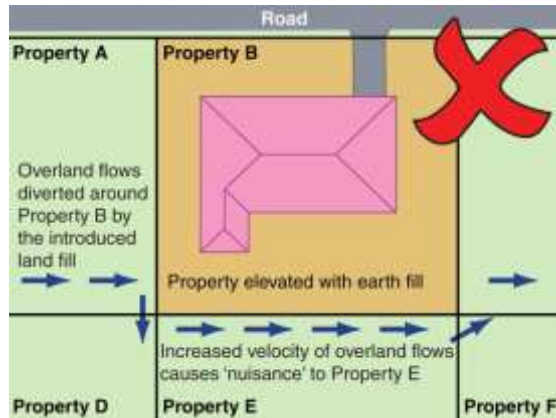


Potentially unlawful diversion of run-off

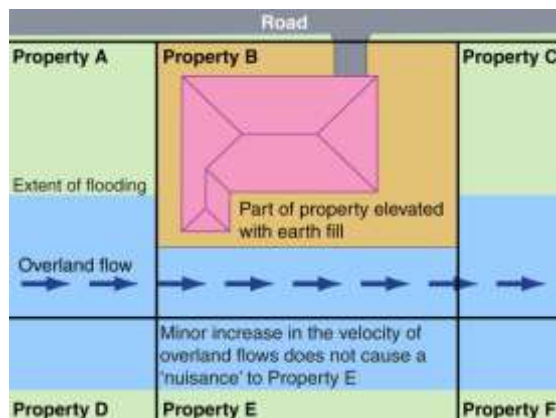


Possible lawful use of land filling

## Examples of lawful and potentially unlawful land filling



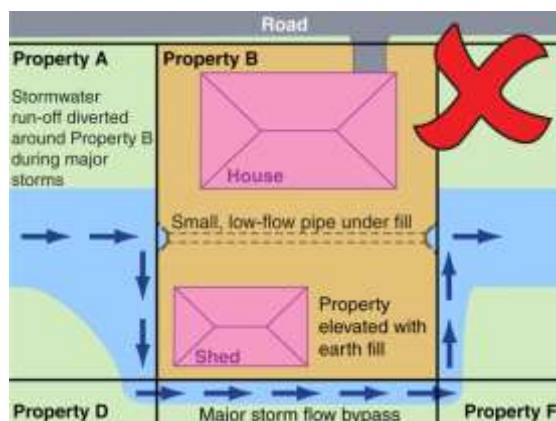
**Case 3: Potentially unlawful land filling**



**Possible lawful use of land filling**



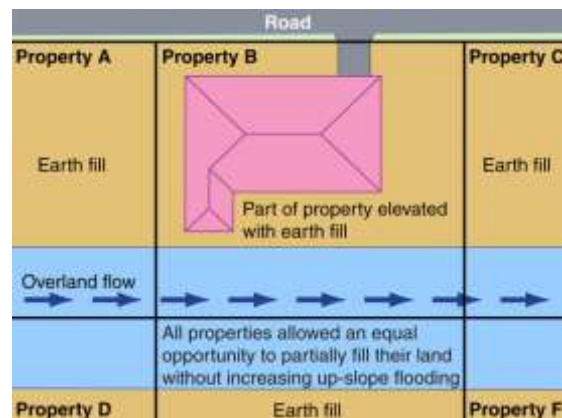
**Case 4: Flow conditions prior to land filling**



**Potentially unlawful blockage of a flow path**

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

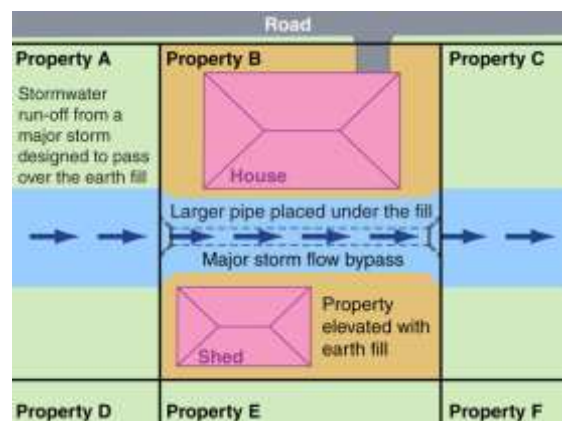
- Council planning schemes may identify long-term land filling proposals that aim to provide all flood-prone residences with the opportunity to elevate their properties.
- Common law principles do not support the concept of 'first in, first served'.
- The filling of one property must:
  - allow other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

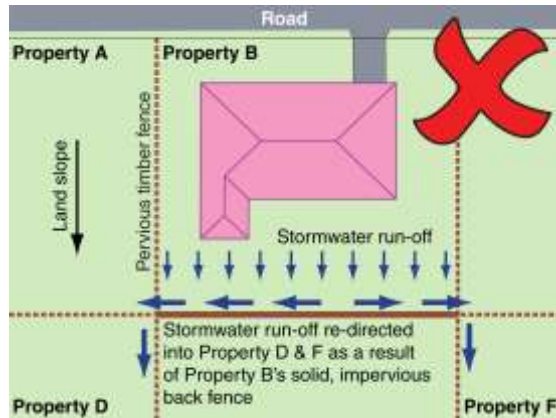
- If land filling is proposed to partially block an overland flow path, then:
  - establish a piped drainage system under the fill to manage the run-off from minor storms, and
  - establish an overland bypass for major storm run-off.
- **Never** build over an overland flow path without providing an alternative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



**Possible lawful use of land filling**



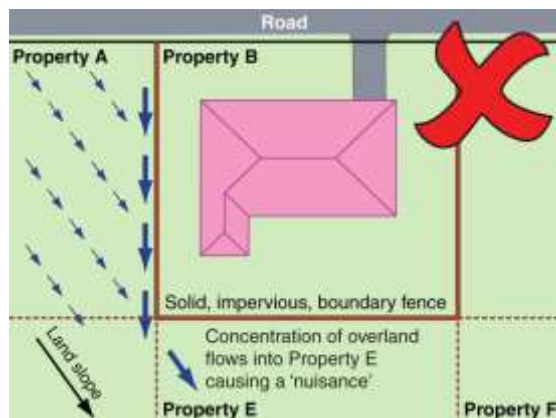
## Examples of potentially unlawful property fencing



Potentially unlawful diversion of run-off

### The redirection of stormwater run-off by a boundary fence

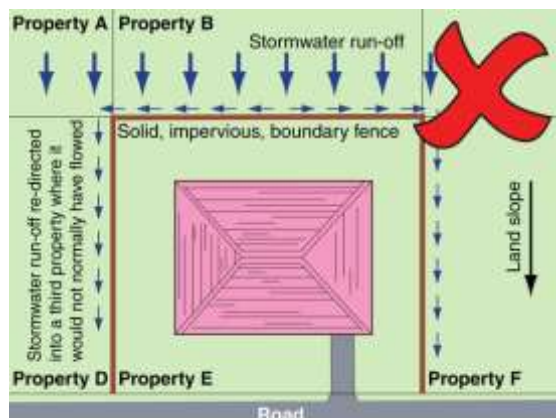
- Solid, impervious fencing is increasingly being used by property owners to:
  - provide increased visual privacy
  - reduce noise pollution
  - reduce the risk of weed/plant growth across property boundaries
- A negative aspect of solid fencing is its potential to redirect natural stormwater run-off.



Potentially unlawful diversion of run-off

### The redirection of stormwater run-off by a boundary fence

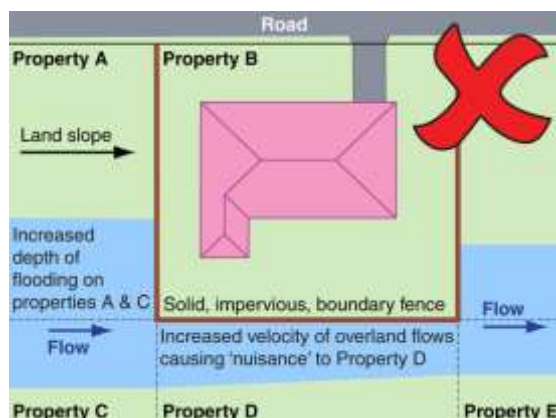
- Modern residential property landscaping typically places garden beds adjacent to the boundary fence, rather than adjacent to the building (in order to discourage white ant activity, and to allow building inspections for white ant activity).
- If a solid boundary fence is installed with a gap left under 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 movement 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

Overland flow

## 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 the current use of the land, but instead may relate to the future value or use of the land, e.g.:
  - if a neighbouring property diverts stormwater onto a part of your property that you currently do not use, but could use in the future, or
  - such actions that 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

<b>1% storm</b>	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.
<b>1 in 100 year storm</b>	<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><b>However</b>, 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>
<b>Acid sulfate soil</b>	A soil type containing significant amounts of iron sulfide (usually pyrite, FeS <sub>2</sub> ) which generates sulfuric acid when exposed to oxygen; typically associated with coastal lowlands (< 5 m AHD) and estuarine floodplains.
<b>Actionable nuisance</b>	A nuisance of such significance that it is likely to cause harm to a person, or cause an adverse effect 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> ).
<b>Aggregate</b>	Washed gravel with a near uniform particle size. Typically used in a concrete mix, or as a rock mulch on garden beds.
<b>Ag-pipe</b>	A flexible, perforated, corrugated drainage pipe commonly used in residential and agricultural sub-drainage. Also known as an AGRICULTURAL (SUB-DRAINAGE) PIPE.
<b>Backwater flooding</b>	Land flooding that involves the spreading of floodwaters laterally into partially-isolated, low-velocity rivulets or areas of a floodplain.
<b>Baseboard drain</b>	A drainage panel used in replacement of a traditional timber skirting baseboard in a room (i.e. at the junction of the wall and floor).
<b>Bio-filter</b>	A stormwater treatment swale or shallow detention system that combines vegetative filtration, soil infiltration and sub-surface filtration through a filter medium.
<b>Bio-retention</b>	A stormwater retention process by which stormwater pollutants are absorbed, modified (treated), or incorporated into organic matter. The retention component of the system involves retaining all or a portion of the processed water for an extended period after the storm.
<b>Building codes</b>	Design codes used by the building industry.
<b>Codes</b>	A publication typically providing technical regulations and specifications that are specifically linked to legislation.
<b>Common law</b>	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.
<b>Concentrated flow</b>	<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>



<b>Creek</b>	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.
<b>Cut and fill allotment</b>	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.
<b>Detention system (stormwater)</b>	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.
<b>Detention tank</b>	Any stormwater detention management system used to temporarily detain stormwater for the purposes of delaying or attenuating outflows.
<b>Dispersive soil</b>	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.
<b>DIY</b>	Means: do it yourself.
<b>Downpipe</b>	The stormwater pipe, usually vertical, that carries roof water from roof gutters to either the ground surface or a sub-surface drainage system.
<b>Drainage</b>	A natural or artificial means of intercepting and removing surface or sub-surface water.  It is noted that in 'plumbing codes' the term 'drainage' often refers to the drainage of sewage or wastewater.
<b>Drainage easement</b>	A state-registered corridor of land where the drainage function is protected by a documented agreement between the landowner and holder of the easement.
<b>Drainage reserve</b>	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.
<b>Easement</b>	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 for which the drainage function is the primary role.
<b>Field inlet</b>	A stormwater inlet to a sub-surface drainage system located within an open area where the water falls vertically into the connecting chamber.
<b>Fill</b>	Earth used to elevate a section of land, or the action of filling land.
<b>Filter cloth</b>	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).
<b>Flood-free home</b>	A home located above the elevation of the probable 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.
<b>Flooding</b>	The inundation of land or structures by water.
<b>French drain</b>	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.
<b>Geotechnical</b>	Of or pertaining to the practical applications of geological science in civil engineering, mining, etc.

<b>Grate</b>	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.
<b>Gross pollutants</b>	A stormwater contaminant that would be retained by a 5 mm mesh screen, usually consisting of litter and organic debris.
<b>Groundwater</b>	The water beneath the surface of the ground.
<b>Habitable room</b>	A household room that is not classified as a 'non-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.
<b>Heavy rainfall</b>	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.
<b>High-set home</b>	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.
<b>Infiltration system</b>	A stormwater management system that promotes the infiltration of stormwater into the in-situ ground. This is different from a 'filtration system' that allows stormwater to pass through an introduced media, such as sand.
<b>Injection waterproofing</b>	A system of injecting a liquid into a crack or cavity under high pressure, after which the liquid hardens to form a watertight seal.
<b>Inter-allotment drainage</b>	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.
<b>Kerb inlet</b>	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.
<b>Lawful</b>	A term generally used when referring to issues relating to the law, e.g. 'a lawful activity'.
<b>Lawful point of discharge</b>	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.
<b>Legal</b>	A term generally used when referring to issues relating to the legal profession, e.g., 'a legal opinion'.
<b>Low-set home</b>	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.
<b>Major storm</b>	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.
<b>Minor storm</b>	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.
<b>Natural flow path</b>	The flow path that water would have taken prior to human interference.

<b>Nuisance (private)</b>	<p>The unlawful interference with a person's use or enjoyment of land, or of some right over, or in connection 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>
<b>On-grade (kerb) inlet</b>	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).
<b>On-site detention</b>	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.
<b>OSD</b>	Means: on-site detention.
<b>Overland flow</b>	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.
<b>PMF</b>	<p>Means: probable maximum flood.</p> <p>The PMF defines the extent of land subject to creek or river flooding.</p>
<b>Pole home</b>	A high-set home where poles are used to elevate the home above the ground such that a substantial air gap exists between the building and the ground.
<b>Porous pavement</b>	A pavement made of materials that allow rainwater to infiltrate and transfer to the underlying sub-soil.
<b>Practicable</b>	Capable of being put into practice, being done, being effected.
<b>Practical</b>	Generally the combined consideration of the practicability of an action <u>and</u> the reasonableness (e.g. financial viability) of that action.
<b>Private certifier</b>	A non-government regulator that certifies (approves) building or plumbing works in accordance with state legislation and local government codes.
<b>Probable maximum flood (PMF)</b>	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.
<b>Property drainage</b>	Rainwater, roof water and stormwater drainage of a property, which includes any constructed sub-surface drainage system.
<b>Rain garden</b>	A bioretention stormwater treatment system integrated into an urban environment and taking the form of a garden bed.
<b>Retention system (stormwater)</b>	Any stormwater collection system 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.
<b>River morphologist</b>	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.
<b>Rock mulching</b>	<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>



<b>Roof water</b>	Stormwater run-off released from roofs.
<b>Run-off</b>	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.
<b>Sag (kerb) inlet</b>	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).
<b>Sarking</b>	A layer of boarding or sheeting material laid under tiles, shingles, or slates for reflective insulation or enhanced water-proofing.
<b>Severe storm</b>	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).
<b>Sewer</b>	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).
<b>Sewer overflow</b>	The discharge of sewage to surface water or to a stormwater drainage system as a result of sewage flow exceeding the sewer capacity (e.g. due to infiltration of rainwater), or as a result of a sewer blockage.
<b>Sheet flow</b>	Flow that passes evenly over the ground as a thin sheet of water as opposed to concentrated flow. Normally occurs on plane surfaces (ground not heavily concaved) and on uniformly grassed areas.
<b>Slab-on-ground construction</b>	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.
<b>Slaking soil</b>	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 erodible and structurally unstable. It does not include the effects of soil dispersion.
<b>Slot drain</b>	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.
<b>Soakage pit</b>	An excavated pit filled with rubble or other open void material into which stormwater is drained for ultimate discharge (infiltration) into the surrounding ground.
<b>Sodic soil</b>	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.
<b>Spoon drain</b>	A drain with a semi-circular cross-section with no associated ridge embankment of soil.
<b>Statute law</b>	Law established by legislative enactments.
<b>Stormwater</b>	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.
<b>Subcritical flow</b>	<p>Subcritical and supercritical flow are technical terms that refer to specific flow conditions of fluids.</p> <p>Technically, it is a free-surface flow condition which has a Froude number less than one, a depth greater than the critical depth, and a velocity less than the critical velocity.</p>

<b>Subsoil</b>	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.
<b>Sub-surface flow</b>	Water that flows through the ground, or within a pipe buried in the ground.
<b>Supercritical flow</b>	A free-surface flow condition which has a Froude number greater than one. An important characteristic of water flow is that the faster the flow velocity, the more resistant the water is to a sudden change in direction. This characteristic is a consequence of the supercritical flow conditions.
<b>Swale</b>	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).
<b>Valley floor</b>	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.
<b>Verge</b>	That portion of the road reserve not covered by the carriageway or footpath.
<b>Watercourse (an 'engineering' definition)</b>	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.
<b>Watercourse (a possible 'legal' definition)</b>	<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 Lyons v. Winter (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>
<b>Watercourse (as recognised by a state government)</b>	<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>
<b>Waterway</b>	A term commonly interchangeable with the term 'watercourse'. The legal definition may vary from state to state, and region to region.

