12 Stormwater and crossings

This chapter deals with managing stormwater networks and outlets that convey stormwater runoff into coastal areas, and providing crossings over coastal waterways. It is primarily concerned with activities adjacent to the immediate foreshore. Further information on natural waterways such as wetlands and saltmarshes can be found in Chapter 6 Coastal landscape management.

Tab photo: Bridge over Carlton River, south-east Tasmania.

12.1 Drainage and stormwater management

This section provides information for improving stormwater management and minimising environmental impacts when installing pipelines and stormwater infrastructure in coastal areas.

As stormwater flows over the ground it picks up a range of pollutants including oils, litter, metals and sediments, which are transported into the coastal area. Pathogens, weed seeds and nutrients can also be transported.

Increased stormwater velocity and volume, as a result of developments and hardening of surfaces (roads, paths etc.) can increase the erosion caused by water runoff and the capacity of flows to carry sediments and pollution into the coastal environment.

Properly managed, stormwater is a significant resource. Good stormwater management involves conserving water and managing pollution at the source, before it reaches waterways. This approach is better and more cost-effective than treating the effects of pollution downstream. Better quality runoff maintains healthy waterways and protects coastal ecosystems and values such as fisheries and recreational opportunities.

Water Sensitive Urban Design (WSUD) is an essential part of low-impact coastal development that is more attuned to natural hydrological and ecological processes. It gives greater emphasis to on-site collection, treatment and utilisation of stormwater flows as part of an integrated system that may be applied in addition to or in lieu of conventional stormwater measures. For more information on WSUD, ***see section 12.1.4***.

When planning developments in coastal areas, ensure that stormwater drainage is carefully designed, constructed and maintained so as to minimise impacts on the natural water cycle and coastal values. This requires responding to the constraints and opportunities of each individual site. Carefully consider site characteristics such as coastal values and processes, soil type, slope, groundwater conditions, rainfall, and the scale and density of development.

More technical detail is available in Water Sensitive Urban Design: Engineering procedures for stormwater management in southern Tasmania (Deeks & Milne 2005) and the Draft state stormwater strategy (Derwent Estuary Program in prep).

12.1.1 Legislation and policies

Common legislation and approval processes are detailed in ***Chapter 1*** and a summary of all relevant legislation is provided in ***Appendices 1 and 2***. Water management is specifically legislated under the *Water Management Act 1999* and the *State Policy on Water Quality Management (1997).*

The *State Policy on Water Quality Management (1997)* requires local governments to prepare and implement a Stormwater Management Plan (SMP) where urban runoff threatens the values, uses and water quality of downstream waterways. The *Draft State Stormwater Strategy* (Derwent Estuary Program, in prep) and *Draft Model Urban Stormwater Management Plan* (DPIWE 2000a) were developed to assist local government to meet its stormwater management obligations under the policy.

12.1.2 Impacts of poorly managed stormwater in coastal environments

Stormwater systems can conserve water and provide a valuable alternative water supply. However poorly managed drainage and stormwater systems may have the following adverse effects in coastal areas:

- Structures may interfere with natural coastal and estuary processes, which can alter the transport of sand by tides, waves and currents and cause erosion or sediment build up.
- Loss of structures or damage to them may be caused by rising sea level (e.g. there may be increased scour around pipes due to increased wave action).
- The nutrients and pollution from drainage outlets may degrade the quality of receiving waters and damage sensitive ecosystems, such as saltmarshes, mudflats, wetlands and fish nursery areas. Nutrients may cause algal blooms and growth of nuisance algae, which can kill seagrass, degrade structures and make rocky shorelines hazardous to pedestrians.
- Pathogens (e.g. faecal bacteria) in stormwater from drainage outlets may contaminate and reduce the recreational amenity of the surrounding coast. Litter in stormwater, such as plastic bags, are visually displeasing and may strangle and starve wildlife.
- Any drainage works in coastal areas risk disturbing acid sulfate soils (ASS). Appropriate investigations

Figure 12.1 Eroded stormwater outlet associated with public access has become a hazard. © Kevin Phillips

should be undertaken to identify any possible occurrence of ASS and management plans developed to address them if disturbance is deemed to be large scale.

12.1.3 Planning for stormwater management

Appropriate stormwater treatment systems will depend on the purpose of the treatment and the characteristics of the site. Aim to use systems that are least likely to cause environmental damage and that maximise benefits to the environment.

Consider drainage and stormwater design at the planning stage, well before any ground disturbance/ construction occurs. The alternative – addressing stormwater design as an additional feature after planning and design has been developed – can both limit opportunities for effective stormwater drainage and increase the cost of the system.

It is cheaper and more effective to reduce and control stormwater pollution at the source. Community education programs can persuade people to clean up litter from streets and wash their cars on lawns and understand the impacts of illegal sewer connections to stormwater systems.

Figure 12.2 Inappropriately sited pipeline on beach is hazardous and looks unsightly. © Leah Page

Coastal stormwater drainage can also be susceptible to damage by wave erosion and/or sand or sediment build-up and can be expensive to maintain. Works on the shoreline may cause increased wind or wave erosion. Structures on or near the shore are vulnerable to damage from sea level rise (Sharples 2006). Therefore planning for drainage and stormwater design is essential. Consult an environmental engineer.

Consult a coastal geomorphologist about placement and the best design and construction methods for the site, including the location of outlets into the sea or waterways, and the distance pipes extend into the water.

Identify any natural or cultural heritage values that require protection. Seek specialist advice – assessments and approvals may be required. Values include Aboriginal heritage, vegetation communities, threatened species and significant wildlife habitat. The Coastal Values data and Natural Values Atlas are helpful resources for natural values. ***Refer to 12.3 Tools and resources.***

Consider alternative stormwater treatment systems (WSUD) to reduce impacts associated with piped systems and design drains, and other stormwater management systems to meet engineering requirements (Australian Standards).

Minimise the number of outlets into the sea or estuary (e.g. rationalise outlets and/or use existing outlets).

Use a variety of methods to treat stormwater to remove a wider range of pollutants and reduce peak flows.

Site selection

When locating stormwater drainage, choose a site that minimises interference with natural systems, especially coastal processes (e.g. movement of sediment by waves and currents) and marine hydrology (seasonal patterns of tidal flushing, etc). Also consider the following issues:

- Avoid unstable or very erodible sites (e.g. dunes and slip-prone areas), natural drainage channels and stream banks.
- Assess the potential for works to mobilise contaminated sediments (e.g. heavy metals).
- Minimise impacts on natural or cultural heritage values (e.g. threatened species or Aboriginal middens).
- Avoid areas infected with phytophthora root rot (e.g. most lowland heath vegetation).
- Avoid areas that can mobilise contaminated sediments (heavy metals) or acid sulfate soils. Disturbing ASS can lead to corrosion and loss of structures.
- Avoid pipes discharging on beaches.
- Avoid obstructing public access to and along the shoreline.

Installation

Before construction works, prepare a works plan that outlines the works to be undertaken and the measures that will be used to minimise the risk of causing environmental damage.

Ensure all staff and contractors are aware of the environmental considerations and any operational constraints required to protect environmental values. Provide supervision to ensure best practice standards are met.

Pipelines

In the past, stormwater outlet pipes have been placed on beaches. This is not appropriate for public access, health and safety reasons. Pipelines crossing the seabed can harm seagrass and other important marine habitats. Installation of pipes into waterways may also need to consider navigation for boats. If pipes into the sea are required, consult an environmental engineer for effective design and seek the advice of a coastal geomorphologist.

Minimise the number of outlets into the sea or estuary. Remove pipes in favour of on-site stormwater systems (e.g. WSUD) or reconnect new networks into existing outfalls where appropriate.

Limit the impacts of existing stormwater pipe outfalls on the shore. Redesign outlets by reducing pipe length on the beach. If there is enough room, discharge the outfall into a vegetated swale for pollution treatment and flow reduction. Where space is limited, encasing the outlet with natural rock can break up concentrated flows, reduce the velocity of flows to non-erosive rates and stabilise the outflow point.

If the pipe is highly visible (e.g. along a beach), natural rock and vegetation placement can conceal the outfall. If the outfall becomes council infrastructure, appropriate design approvals are required.

Gross Pollutant Traps

Gross pollutant traps (GPTs) – structural litter and pollution collection devices – have been installed on the end of outfalls on beaches to improve water quality. Locating them in the tidal zone has caused problems with sand blocking up the GPTs. Better results can be achieved by locating them near the pollution source, e.g. the drainage networks from a shopping centre, service station or car park. Litter traps installed on individual stormwater drainage pits are suitable for smaller stormwater catchments or where there are litter hotspots.

Figure 12.3 Inappropriate siting of stormwater outfall on beach causes scouring and impacts on amenity and access. © DPIPWE

12.1.4 Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is the design of stormwater infrastructure that aims to minimise impacts of developments on waterways and the coast. This is achieved by source control strategies that treat, store, and infiltrate stormwater runoff on-site before it can affect receiving waters. This is a change from the traditional approach, which was to get water 'piped and delivered off site' as quickly as possible.

WSUD represents best practice in Australia for water conservation and stormwater management and is ideally suited to developments on the coast incorporating specifically constructed elements including rainwater tanks, permeable pavements, vegetated swales, biofiltration systems ('raingardens'), green roofs and stormwater treatment wetlands.

Many WSUD methods are low-cost and can be retrofitted into existing catchments or incorporated at the design stage of new developments, avoiding the need for installing expensive piped stormwater networks and associated works e.g. pavements, kerbs and other infrastructure.

WSUD structures can be attractive parts of the landscape, adding aesthetic values to housing developments.

WSUD key principles:

- protecting water quality of surface and ground waters
- maintaining the natural hydrologic behaviour of catchments
- protecting natural features and ecological processes
- minimising demand on potable water supply systems
- integrating water into the landscape to enhance visual, social, cultural and ecological values
- collecting, treating and/or reusing run-off, including roof water and other stormwater
- reusing treated effluent and minimising wastewater generation
- increasing social amenity in urban areas through multipurpose green space and landscaping

A well designed WSUD system can result in significant reductions of stormwater pollutants i.e. an 80% reduction in sediments, 70% reduction in litter and substantial reductions in nutrients, heavy metals and hydrocarbon loads. In Tasmania (as in other Australian states such as Victoria and Queensland), the removal of the following key pollutants is recommended for stormwater management targets that WSUD systems need to meet:

- 80% reduction in the average annual load of total suspended solids (TSS) based on typical urban stormwater TSS concentrations.
- 45% reduction in the average annual load of total phosphorus (TP) based on typical urban stormwater TP concentrations.
- 45% reduction in the average annual load of total nitrogen (TN) based on typical urban stormwater TN concentrations.

To meet these targets, WSUD systems should conform to accepted Tasmanian and Australian practices, such as site-specific modelling of pollutant-generation against different WSUD techniques using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) proprietary software or the guidance provided in *Water sensitive urban design: Engineering procedures for stormwater management in Southern Tasmania* (Derwent Estuary Program 2005). Stormwater flow management estimates need to be prepared according to methodologies described in *Australian Rainfall and Runoff* (Engineering Australia 2004) or through catchment modelling completed by a suitable professional.

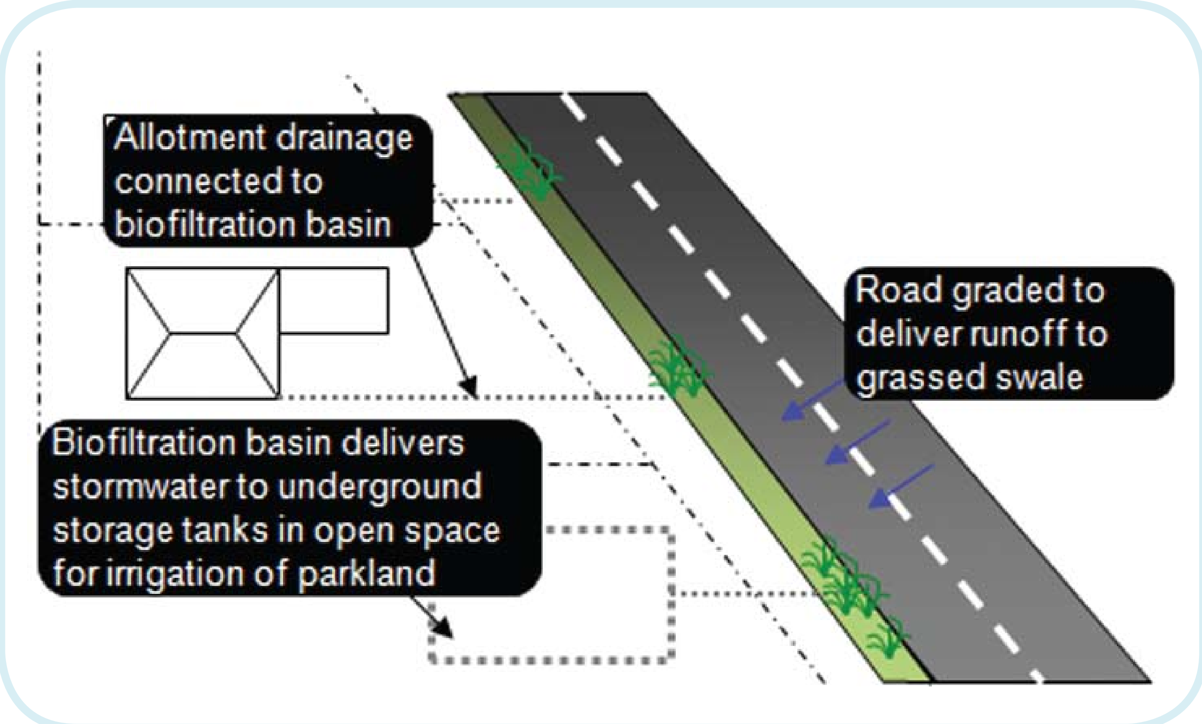
12.1.5 Treatment trains

Stormwater is best managed distributing a combination of WSUD features within a development or catchment, creating a treatment train – a series of treatment systems that complement one another to achieve clean stormwater and reduce peak flows in a catchment.

Each stormwater treatment measure operates over a particular hydraulic loading rate and pollutant size range, treating gross particulates (litter, larger organic matter, etc.) first, then coarse particulates (sediment) and finally fine, colloidal and dissolved material.

To be most effective, the selection and placement of the different WSUD systems in the treatment train should be determined during the site planning and design phase. Treatment trains can be applied at a wide range of scales within a development, such as housing layout (including design of single residential allotments and subdivisions) and streetscape layout (including road and car park design).

Figure 12.4 Example of stormwater treatment train strategy for a typical suburban street. Source: Draft state stormwater strategy (Derwent Estuary Program, in prep)



Case Study 12.1 Water Sensitive Urban Design – Cornelian Bay

Stormwater is treated by a number of WSUD methods before it enters Cornelian Bay.

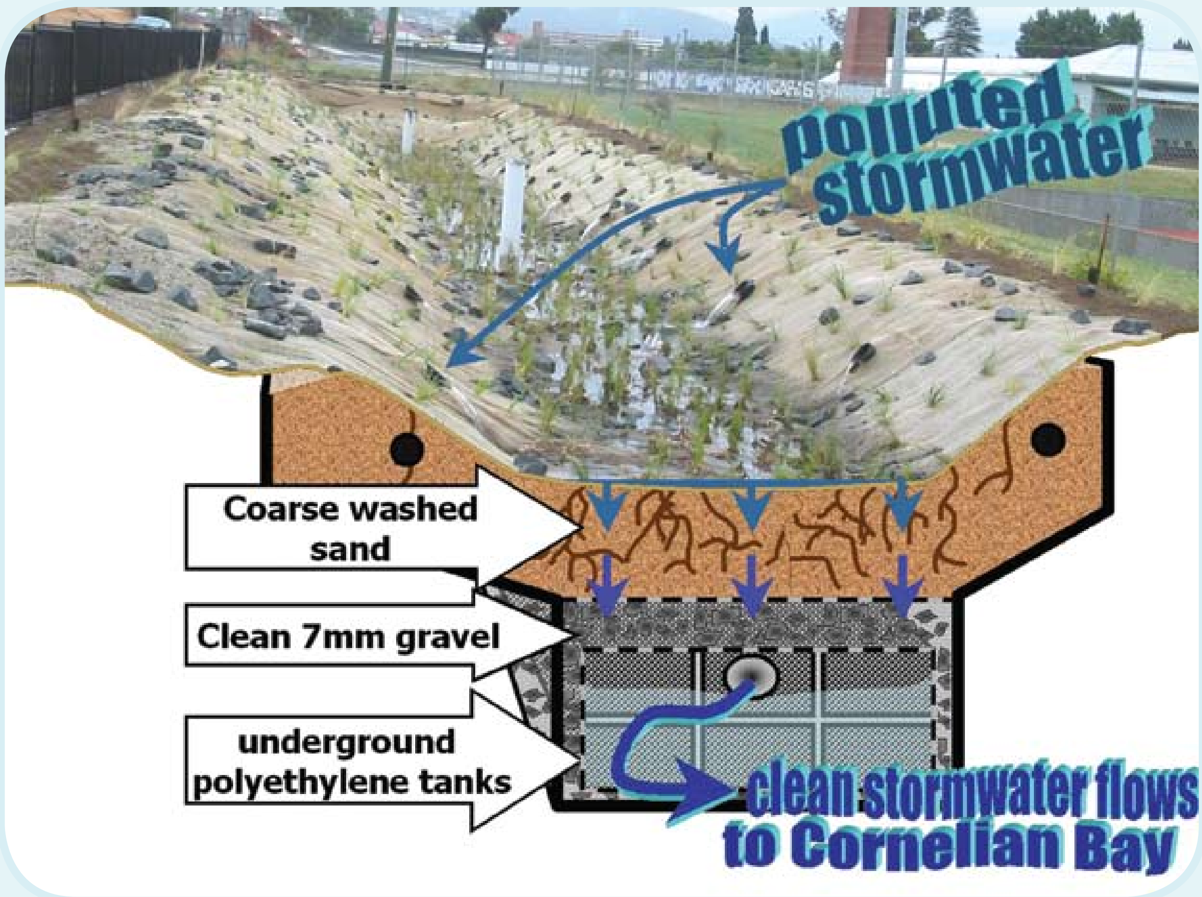
First it is filtered by an underground pollutant trap, which removes litter, oil and coarse sediment.

Water is filtered again as it passes through a vegetated channel and yet again as it percolates through sand, which removes fine sediments and their attached pollutants.

After passing through the sand, the water travels through a layer of gravel underlain by a filtering 'geofabric', before entering the subsurface tanks.

In the tanks, a biofilm (a layer of bacteria) traps remaining pollutants and breaks them down into harmless substances.

Figure 12.5 Cornelian Bay integrated stormwater treatment train, first rainfall after installation. Plants have since become more established. © Hobart City Council



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Case Study 12.2 Water Sensitive Urban Design – New Town Bay

A floating litter trap was installed near the mouth of New Town Rivulet to remove gross pollutants. The trap is easily serviced and prevents litter from the urban environment being washed into the Derwent Estuary.

Refer to the Hobart City Council and Derwent Estuary websites

Figure 12.6 New Town Bay floating litter trap. © Hobart City Council

Case Study 12.3 Stormwater wetlands – Lauderdale

The project involved the relocation and lining of existing stormwater drains and the construction of a treatment wetland with six permanent pools and a meandering drainage channel on a 5ha site. The project's goal was to improve the quality of the residential stormwater discharged to Lauderdale Canal and Ralphs Bay – an important migratory bird habitat.

Figure 12.7 Lauderdale stormwater wetlands. © John Chrispijn

Figure 12.8 The stormwater rain garden is effective and looks great. © John Chrispijn

Case Study 12.4 Small bioretention basin in North Hobart

A small biofiltration system (rain garden) installed in Lefroy St, North Hobart is capturing and treating runoff from a Council owned car park 1400 m^2 in size. Natives were used, *Isolepsis nodosa* (knobby clubrush) and *Lomandra longifolia* (mat rush, sagg), to plant out the rain garden. A 100mm slotted drain pipe at the base of the rain garden directs the treated stormwater into the adjoining Providence Gully Rivulet.

12.1.6 Ongoing maintenance of stormwater structures

All structures should be maintained regularly to minimise the risk of causing erosion, and obstructing the passage of pedestrians, fish and other fauna. Debris and sediment may block narrow stormwater pipes, particularly if trash screens have been installed. Inspections and maintenance should be carried out on a regular basis and after heavy rainfall or storm events.

Inspection and maintenance should include the following.

- Check for erosion around the stormwater structure and check that structures are secure and not becoming a hazard to the public.
- Check pipe openings and litter traps, and remove debris to allow passage of fish and other animals. Gross pollutant traps will require regular removal of debris.
- Maintain the vegetation around the structure. Remove weeds and ensure vegetation is growing where it should and not interfering with the useability and function of the structure.

Vegetation maintenance around stormwater structures

Avoid as far as possible using herbicides along or in drains (as this causes pollution, kills frogs and exposes the soil to erosion). To maintain grass swales, slash the vegetation rather than using herbicides. Ensure that slashed material is removed and does not get into the waterway. Sometimes it is safe to spread slashed material on site away from the waterway, but only if it doesn't contain ripe weed seeds. ***Refer to Chapter 7 Vegetation management.***

If spraying is required near waterways, check that the appropriate chemical is used and avoid spraying in the breeding seasons of frogs and other animals. Use only herbicides registered for use near waterways. If in doubt, contact a Regional Weed Management Officer at DPIPWE.

Follow the Codes of practice, guidelines and information sheets for using herbicides, available from the DPIPWE biosecurity website.

Refer also to Transport Tasmania (2003) *Roadworks specification R34 –Drainage maintenance.*

12.1.7 Climate change and stormwater management

Climate change makes it more important than ever to employ water-sensitive urban designs in stormwater management practices. It also makes the protection of natural and cultural coastal values during coastal management works critical, as climate change places increased pressure on coastal ecosystems.

New structures on the coast need to take into account the latest Intergovernmental Panel on Climate Change (IPCC) sea level rise predictions (which are currently being revised upwards). Structures will be susceptible to wave action and storm surges if not sited appropriately.

Sea level rise will also result in increased inundation of low-lying coastal areas that might impact on the effectiveness of stormwater treatment facilities. King tide events already cause localised flooding when seawater is pushed back up into the stormwater systems of more urban coastal environments. It is important to seek expert advice and use the latest information and modelling when planning stormwater facilities or structures. Refer to *Indicative mapping of Tasmanian coastal vulnerability to climate change and sea-level rise: Explanatory report* (Sharples 2006).

12.2 Crossings – bridges, causeways and culverts

This section describes design and installation of waterway crossings, such as bridges, causeways and culverts in coastal areas and techniques for minimising impacts on coastal processes, values and ecosystems. Habitat, vegetation and cultural heritage values can be damaged during construction of waterway crossings. Construction can also cause significant bank and bed disturbance in waterways. These structures can create barriers to fish movement and ongoing bank erosion.

All crossings require careful design, siting and construction to cater for the special conditions and values at their location and the coastal processes such as waves, tides and sand movement. Such structures are vulnerable to damage from coastal processes; when designing them, planners and engineers need to consider projected sea level rise and increased storminess associated with climate change.

Appropriately designed causeways or culverts will maintain tidal flows and allow the passage of fish and other animals. Well-designed bridges and causeways can be attractive parts of the landscape and serve as useful viewing points and fishing places.

12.2.1 Legislation and approvals

There is a range of legislation that provides for protection of coastal values when undertaking works on the coast. In addition to legislation mentioned in ***section 12.1.1, Chapter 1*** provides an overview of common legislation and ***Appendices 1 and 2*** provide information on all the coastal legislation. Of particular relevance to crossings is the *Inland Fisheries Act 1995,* which prevents the obstruction of fish passage.

Structures on the shoreline often cross over land and water that is governed by different authorities. The Crown owns the seabed and water, regardless of whether the landowner has a high water mark title. Structures below high water mark also require DPIPWE Crown Land Services approval and a Crown Land lease. Depending on the structure's size and nature, DPIPWE may require submission of a Development Proposal and Environmental Impact Statement.

If the structure crosses land managed by the Parks and Wildlife Service (PWS), under the *National Parks and Reserves Management Act 2002,* approval of PWS will be required. This is necessary before submission of council planning applications.

Necessary approvals may include council planning and building approvals, and permits under the local planning scheme.

12.2.2 Types of crossings

The type of crossing selected will depend on its purpose and the characteristics of the site. In all cases, the type of structure used should cause the least amount of environmental damage. In descending order of preference for crossings over watercourses, choose a bridge, arched culvert, open-bottom box culvert, closed-bottom box culvert, or pipe culvert (Gallagher 2003).

Bridges

Bridges are raised structures that carry a path or a road over a waterway. Typically, they are used on estuaries or rivers with clearly defined drainage channels. Usually a bridge has few or no structures in the water, so it does not impede flows.

Bridges are the most appropriate crossings for sites with:

- actively eroding banks
- a channel too steep for a culvert
- steep banks that would need considerable infilling if a culvert was used
- threatened species, fish habitat or aquatic vegetation.

Culverts

Culverts are arched, boxed or piped conduits that allow water to pass under a road or other structure. They are usually made of concrete or galvanised corrugated steel pipe. The location and size of the culvert is determined by the stream flows and the need for it to be safe during high flows. Like bridges, some large box and arch culverts do not significantly alter the riverbed or the width of the channel.

Many aquatic animals avoid or are unable to go through culverts. Culverts channel the water flow over the smooth concrete surface and increase flow velocity. Poorly designed or poorly embedded culverts prevent upstream movement and natural mixing of aquatic species.

Wherever possible, use bridges instead of culverts. Try alternative inverted U-shaped designs or irregular shapes. If round culverts are necessary they should be fully embedded in the stream bed and ideally should have an artificial substrate provided down the mid-line of the pipe (e.g. cemented rocky gravel).

Causeways

Causeways are structures that raise the base of the river or estuary bed. There are culverts underneath to allow water to go through the causeway when flows are low, but it may be inundated during floods

Figure 12.9 The Sorell causeway bisects Pittwater-Orielton Lagoon, a Ramsar site in south-east Tasmania. © Leah Page

or by storm waves. Typically, causeways are located on waterways with intermittent flows, poorly defined drainage channels, and wide shallow estuaries where it is too expensive to construct a bridge.

12.2.3 Impacts of crossings on coastal environments

Interfering with natural coastal and estuarine processes may alter the transport of sand by tides, waves and currents. Bridge and causeway construction across estuaries and other shorelines in the past has sometimes involved filling in wetlands and destroying vegetation and intertidal habitat.

Causeways across estuaries may severely restrict tidal flows and reduce the tidal prism (the volume of water moving in and out of the estuary). This may increase the rates of siltation and deterioration in water quality, which in turn may damage seagrass beds and other habitats.

The reduced fluctuation in tide levels and velocities upstream from a causeway, together with highly reduced salinity levels, may lead to considerable changes in plant communities and animals. If they restrict flows, causeways may cause more frequent local flooding.

Loss of structures or damage may be caused by rising sea level (e.g. there may be increased scour around structures due to increased wave action).

Poorly designed bridge and causeway approaches may erode and deposit large amounts of sediment and road pollutants into the waterway or impede sediment flushing.

Bridge footings and bank armouring (e.g. rocks) may stop animals moving along the banks. This may force animals to cross nearby roads, which increases their chances of being killed.

Causeways and culverts may hamper fish migration and movement of platypus and water rats (e.g. where there are high velocities through narrow pipes, or a steep drop-off from a culvert). If several small culvert pipes are used rather than one large barrel, they might be too small or dark for fish to swim through.

Debris and sediment may block narrow culverts, particularly if trash screens or stock barriers have been installed. The accumulated debris could stop migratory species passing through by creating a physical barrier or increasing flow velocity.

12.2.4 Planning for crossings in coastal environments

Before constructing crossings, prepare a works plan that outlines the works to be undertaken and the measures that will be used to minimise the risk of causing environmental damage.

- Ensure that all planning and approvals processes have been met.
- Consult coastal geomorphologists, engineers and hydrologists about the crossing design and placement. All structures should be designed by a suitably experienced engineer in consultation with a coastal geomorphologist.
- Seek specialist advice about fauna, flora and aquatic values in the area. Design crossings to accommodate requirements of threatened or highly valued species. Schedule works to avoid disturbance to sensitive species such as shorebirds. Consider temporary relocation of threatened species if appropriate. ***Refer to Case Study 10.1 Protecting threatened seastars during construction works in south-east Tasmania.***
- Identify any cultural heritage values that may require protection. Consult with Heritage Tasmania and Aboriginal Heritage Tasmania, who

can advise whether there are any values in the area.

- Structures should generally comply with the relevant requirements (e.g. Australian Standards, Austroads and Transport Tasmania guidelines).
- Align structures perpendicular to the direction/s of the prevailing waves and sediment movement, wherever possible. This will minimise obstruction of the movement of sediment.
- Provide for navigation, where boating occurs.
- Preserve the connectivity of the waterway by minimising any constriction of water flow and simulating natural channels and water flows.
- Plan works in watercourses and estuaries to coincide with low water flows, unless this may have adverse effects on plant communities and animals (especially threatened aquatic, estuarine and marine species).
- Avoid works in areas infected with phytophthora root rot. Implement good hygiene practices to avoid spreading weeds and diseases on machinery, tools and equipment. Seek expert advice in areas with pathogens.
- Restore the natural vegetation as soon as possible, to minimise the potential for bank erosion. It may be necessary to use geotextiles to stabilise banks.

Site selection for crossings

Choosing the appropriate site is critical for structures that extend across the shore and into the sea. The structures are susceptible to damage by wave erosion and/or sediment build-up and can be expensive to maintain. Works on the shoreline may also cause increased wind erosion.

- Choose a site that minimises interference with natural coastal systems and processes (including wave action and seasonal cycles of sediment accretion/erosion) and marine hydrology (seasonal patterns of tidal flushing, currents, etc.).
- Avoid unstable areas such as dunes, slip-prone areas, very erodible soils, natural drainage channels and stream banks. Avoid shoreline or marine vegetation, floodplains, wetlands and other sensitive sites, as far as possible.
- Choose sites away from significant cultural or natural heritage values as identified during planning.
- Avoid areas where the works could mobilise contaminated sediments or acid sulfate soils (ASS). Disturbing ASS may lead to environmental damage that requires remediation and also corrosion and loss of structures. ***Refer to section 11.4 Acid sulfate soils.***
- Site a causeway on a straight stretch of the waterway with a minimal gradient.
- Site a causeway on a stable substrate where there is scour-resistant material immediately downstream.

12.2.5 Installing and constructing crossings

All works crews and contractors should be briefed on the environmental standards to be met by the project and adequate supervision should be provided to ensure these standards are met.

Minimise disturbance to the shoreline or to riverbanks, bed and natural flows. Avoid deep box cuts on the approaches to bridges and causeways.

Minimise erosion by protecting estuary banks or streambanks and bridge or causeway embankments with concrete, timber, geotextiles, vegetation or rocks where appropriate. Stabilise watercourse beds (e.g. by armouring the bed with large rocks). Use energy dissipaters if there is insufficient natural protection against scouring or erosion, but only where they do not obstruct the passage of aquatic fauna. Obtain advice from a coastal engineer about the appropriate materials and methods for the site.

Employ sediment and erosion control measures during construction, to minimise sediment flow into the waterway. Install cross-drains (at right angles to the roads) to drain water from the approach road into a sediment trap or the roadside vegetation. Place the drains at least 20m away from the crossing.

Both ends of the causeway should be 'keyed in' to the bank for 3–5m. Construct the surface of the causeway with erosion-proof material, such as interlocking angular rock or concrete or flexmat (a concrete and webbing mat).

Operate construction equipment in a manner that causes the least disturbance to the watercourse or estuarine bed and banks.

- Keep machinery out of the channel as much as possible, and minimise entry points.
- Do not dump construction materials (e.g. concrete) or push fill into the water.
- Locate surplus fill at least 10m from the shoreline, estuary or watercourse banks, separated by an effective filter strip of vegetation.

Keep water away from fresh concrete for at least seven days, where feasible. As fresh concrete is highly alkaline, it can make water uninhabitable for fish and other fauna. Some fast-drying mixes may allow a shorter curing time.

Figure 12.10 Small-scale private crossing over saltmarsh area - whilst in poor condition, it does allow the free passage of water. © Leah Page

12.2.6 Special considerations for bridges and causeways on the coast

These guidelines provide some points to consider to produce the best possible outcome for the coastal environment.

Design and construct structures to accommodate all water flow conditions. Design permanent bridges and causeways over rivers and estuaries to withstand the one-in-50-year flood level and storm surges. Consider the latest IPCC predictions for sea level rise. Specialist advice will be needed on a range of technical issues (e.g. hydrology and hydraulics).

Design and space the causeway openings to maximise tidal flushing.

Preserve the waterway's natural hydraulic regime (pattern of water flows) as much as possible. Place bridge piers and footings above the high water mark, to avoid constricting the channel and reducing the flow area. If bridge piers and footings must be placed in the channel, align them parallel to the flow so that the flow is not directed onto the banks. Use the minimum number of piers, shaped to minimise eddying and scouring of the waterway. Include erosion protection if scouring is likely to occur.

Consult the Inland Fisheries Service to ensure the passage of fish will be provided for. Design structures and time works to minimise disturbance to the passage of fish and other aquatic fauna. Provide enough space under the bridge for animals to walk along the riverbanks, where practicable. Seek specialist advice and refer to the design considerations in the *Policy and guidelines for fish friendly waterway crossings* (NSW Department of Primary Industries) and *Why do fish need to cross the road?* (Fairfull & Witheridge 2003).

On a multi-lane bridge, if the risk of pollution from road runoff is minimal, consider using grated decking so that light and moisture can penetrate.

If the bridge is to be used by the public and heavy vehicles, detailed design drawings should be submitted that satisfy all the relevant Australian Standards and are certified by a qualified engineer.

Design structures to look attractive and to suit the coastal landscape, as well as provide access for vehicles, bicycles and pedestrians. Wherever appropriate and affordable, allow for safe fishing places on a bridge or causeway.

12.2.7 Special considerations for culverts

These guidelines provide some points to consider, to produce the best possible outcome for the coastal environment.

When planning watercourse crossings where fish are likely to be present, consult a specialist and seek technical information on culvert design and placement. The *Forest Practices Code* (Forest Practices Board 2000) has design and installation requirements (page 15) to assist the passage of aquatic freshwater fauna, some of which will apply to estuarine species as well. Consult the Inland Fisheries Service to ensure the passage of fish will be provided for appropriately.

Ensure the culvert's capacity can accommodate peak flow volumes, so that the top of the inlet is not submerged in peak flows by more than 0.5m (in low to moderate-high erodibility class soils) or 0.1m (in high to very high erodibility class soils), unless measures are used to protect against erosion where the water discharges at the downstream end.

Open-bottom culverts with the natural streambed running through them are preferable to other culverts. Ensure they do not break up the streambed

12.2

material, and are large enough not to constrict flows or trap debris during normal flow conditions.

If an open-bottom culvert is not suitable:

- One large culvert spanning the width of the waterway is preferable to two or more small culverts, as it is usually more hydraulically efficient.
- Ensure culvert pipes are of sufficient strength (e.g. reinforced concrete pipes) to handle anticipated bearing loads. The minimum diameter of culvert pipes should be 300mm (or 375mm in areas with high or very high erodibility class soils, where the risk of culvert blockage or failure is high).
- If multiple culverts are needed to span the riverbed, one or more should be slightly lower than the others to concentrate low flows and allow fish to swim through.
- Place the culvert perpendicular to the flow, to minimise the length needed (less than 4m) and to allow fish to swim through.
- Ensure the culvert gradient is gently sloping, similar to the stream gradient. To allow fish passage, avoid using culverts on a waterway with a gradient of more than 2% (1:50). The gradient immediately downstream of the culvert should be less than 5% (1:20), so fish can approach the culvert outlet.
- If possible, design the culvert so that its hydraulics (water flows) are similar to those of the stream, and the weakest fish species can swim through. The water depth should allow the largest fish species to remain submerged.
- Ensure the culvert has at least 600mm of space above the typical base flows (low flows of the stream), so that it is light enough inside to encourage fish to enter and swim through.
- Ensure that water velocities in the culvert are similar to those at the site before the culvert was constructed. There should also be no differences in the flow rates upstream, inside the culvert, and downstream.
- Cementing baffles or large angular rocks (typical of the area) along the base of longer concrete culverts will reduce flow velocities and allow aquatic animals to pass through.
- Lining the base of the culvert with a rough concrete finish and/or natural substrate will increase turbulence and make it easier for fish to swim through. Velocities of less than 0.3m per second will allow most native fish to swim through a 5m culvert.

Figure 12.11 Inappropriate culvert is sited poorly and does not allow passage of fish at low flows. Source: Wetlands and waterways manual (Gallagher 2003)

- To control erosion at the outlet, place a rip-rap apron (V-shaped to allow fish passage at low water levels) at a distance of up to six times the culvert diameter beyond the outlet, particularly if the slope of the riverbed is greater than 2% (1 in 50).
- Ensure the capacity is large enough to accommodate the anticipated debris and sediment load.

12.2.8 Ongoing maintenance of crossings

All crossings should be maintained regularly to minimise the risk of causing erosion and flooding, or obstructing the passage of fish and other animals. Regular inspections and maintenance should be carried out on new crossings, after storms and periods of high flow, and before fish and other animals begin migrating.

Minimise disturbance to the passage of fish and other aquatic fauna during maintenance works.

Refer to Transport Tasmania's *Roadworks specification R34 – Drainage maintenance and Austroads AP-127/97: Concrete structures durability, inspection and maintenance procedures –Position paper.*

Figure 12.12 Wherever possible box culverts are best as they can accommodate high flows and are open at the bottom to allow for natural sediment beds. © Leah Page

Inspection and maintenance should include the following:

- Clear debris from the crossing's surface, entrance and exit.
- Remove debris and sediment from culverts, if more than a third of the entrance is blocked, to allow passage of fish and other animals.
- Check erosion is not a problem.
- Check structures are secure and not becoming a hazard to the public.

12.3 Tools and resources

Complete details of all printed publications listed here are provided in a reference list at the end of the Manual. Other tools and resources including websites are collated in ***Appendix 5***.

Drainage and stormwater

A model stormwater management plan for Hobart Regional Councils – a focus on the New Town Rivulet Catchment (Derwent Estuary Program 2004)

www.derwentestuary.org.au

Aboriginal Heritage Tasmania

Desktop search for Aboriginal heritage sites

www.aboriginalheritage.tas.gov.au

Australian Runoff Quality (ARQ) (Institution of Engineers, Australia 1987, reprinted 1998)

A broad design guideline produced by the National Committee on Water Engineering. Provides an overview of good practice in managing urban stormwater in Australia and contains:

- procedures for estimating stormwater contaminants
- design guidelines for stormwater quantity and quality management improvement methods (e.g. gross pollutant traps, vegetated swales and buffer strips and other aspects of water sensitive urban design)
- procedures for estimating the performance of these practices
- advice about developing integrated urban water cycle management practices
- advice about hydrocarbon management

Coastal Values data

Vegetation, species habitat and geomorphic values data for a 100m wide coastal strip of the northern, southern and north western Tasmania Natural Resource Management regions. Available on the LIST.

www.thelist.tas.gov.au

Draft State Stormwater Strategy (Derwent Estuary Program in prep)

Herbicide use

DPIPWE Codes of practice, guidelines and information sheets for using herbicides

- Code of practice for ground spraying
- Code of practice for spraying in public spaces
- Rivercare guideline for the use of herbicides near waterways and wetlands

www.dpipwe.tas.gov.au (Go to Biosecurity > Agricultural & veterinary chemicals > Codes of practice & guidelines)

Hobart City Council website

www.hobartcity.com.au

Indicative mapping of Tasmanian coastal vulnerability to climate change and sea level rise (Sharples 2006)

Model for urban stormwater improvement conceptualisation (MUSIC)

A proprietary software product. MUSIC is a user-friendly tool designed to meet the needs of urban stormwater engineers, planners, policy staff and managers in consultancies and state, regional and local government agencies.

Natural Values Atlas

The Natural Values Atlas provides authoritative, comprehensive information on Tasmania's natural values. Download a free registration form from the website to access

https://www.naturalvaluesatlas.tas.gov.au

Planning guidelines for the Tamar Estuary and foreshore (Watchorn 2000)

Smartline or coastal vulnerability maps

Maps of coastal landform types and their vulnerability to sea level rise can be found under 'Climate Change' layers on the LIST and the OzCoasts website. The data is presented as a 'smart line' following the coastline, with information on the geology of the coast readily interpreted for particular coastal areas.

www.thelist.tas.gov.au

www.ozcoasts.org.au

Transport Tasmania

- Roadwork specification R92 – Underground service facilities
- Roadworks specification R 32 Drainage: Culverts, pipelines and structures
- Roadworks specification R34 – Drainage maintenance

www.transport.tas.gov.au

- Bridgeworks specifications (whole series) http://www.transport.tas.gov.au/road/specifications/bridgeworks_specifications

12.3

Water sensitive urban design: Engineering procedures for stormwater management in southern Tasmania (Deeks & Milne 2005)

Waterways and wetlands works manual: Environmental best practice guidelines for undertaking works in waterways and wetlands in Tasmania. (Gallagher 2003)

Crossings

Aboriginal Heritage Tasmania

Desktop search for Aboriginal heritage sites

www.aboriginalheritage.tas.gov.au

Austroads

Austroads 1997, AP-127/97: Concrete structures durability, inspection and maintenance procedures – Position paper

Available for download from the Austroads website. Registration is required for download. Registration and products are free.

http://www.onlinepublications.austroads.com.au

Fish passage at culverts: A review, with possible solutions for New Zealand indigenous species (Boubée et al. 1999)

http://www.doc.govt.nz/upload/documents/science-and-technical/culverts01.pdf

Forest Practices Code (Forest Practices Board 2000)

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Policy and guidelines for fish friendly waterway crossings (New South Wales, Department of Primary Industries, n.d.)

Waterways and wetlands works manual: Environmental best practice guidelines for undertaking works in waterways and wetlands in Tasmania. (Gallagher 2003)

Why do fish need to cross the road? Fish passage requirements for waterway crossings (Fairfull & Witheridge 2003)

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/202693/Why-do-fish-need-to-cross-the-road_booklet.pdf