10 Essential services

The Commission's interim report examined the adequacy of measures to manage the supply of essential services including power, water and communications during the 2010/2011 floods.

This chapter addresses the damage caused by the 2010/2011 floods to sewerage, stormwater, electricity, telecommunications and roads and rail infrastructure. It considers how damage to this essential services infrastructure can be minimised in future floods, with a particular emphasis on planning and design measures.

10.1 Sewage and sewerage

10.1.1 Definitions

'Sewage' is human waste product, sometimes referred to as 'wastewater'.

'Sewerage infrastructure' or the 'sewerage system' is the infrastructure through which sewage flows, for example pipes, pump stations and treatment facilities. In the material before the Commission it is sometimes referred to as 'wastewater infrastructure'.

'Effluent' is sewage in a liquid form that has been treated or partially treated.

10.1.2 The role of sewerage infrastructure

By enabling the safe collection and treatment of human waste, sewerage systems play a critical role in ensuring the health of the community and the environment. These systems were damaged or inundated in a number of locations in the 2010/2011 floods, with, in some locations, the discharge of untreated sewage into residential areas, public parks and waterways.

Sewage disposal occurs either through a centralised public sewerage system or through smaller independent systems, commonly referred to as septic systems, located on private properties (usually in rural areas with more dispersed populations).

A public sewerage system comprises an integrated sewage collection and treatment network. Sewage is collected from individual private premises by service branch lines that transmit the collected material to larger mains. The mains then feed into pump stations and sewers that connect to sewage treatment plants.[1] Within the sewage treatment plants, sewage is passed through a series of biological and chemical treatments that render it safe to be discharged into a waterway or to be used as recycled water.[2]

Public sewerage systems are managed by public authorities. In most parts of Queensland the council is the responsible authority, except in the south-east where sewerage is managed by specialised service providers known as 'distributor-retailers' that are responsible for catchment areas spanning several councils. The councils and distributor-retailers are responsible for the sewerage system up to the point where the sewerage infrastructure connects to the boundary of private properties. Generally, sewerage infrastructure and septic systems on private land are the responsibility of the property owner.

Damage to, or the inundation of, any part of a sewerage system may result in the discharge of untreated sewage, presenting a hazard to health and to the environment, even when diluted. Discharges from public sewerage systems are a particular concern, given the large volume of sewage that passes through them.

10.1.3 The regulatory structure applicable to sewerage infrastructure

A number of pieces of legislation regulate sewerage infrastructure.

The *Water Supply (Safety and Reliability) Act 2008* provides the regulatory framework for water and sewerage services in Queensland and sets out the functions and powers of water and sewerage service providers.

The *Sustainable Planning Act 2009* provides the planning framework for the development of water and sewerage infrastructure. Under the Act, any new infrastructure or upgrades to existing infrastructure may be subject to development assessment.

The *Plumbing and Drainage Act 2002* establishes the legislative framework for plumbing and drainage and on-site sewerage facilities in Queensland. It provides a mechanism for enforcing compliance with standards for on-site sewerage work and facilities.

The *Local Government Act 2009* and the *City of Brisbane Act 2010* prohibit the connection of any part of the sewerage system to the stormwater system and give councils the power to take enforcement action to rectify illegal connections.

The *Environmental Protection Act 1994* (and related legislation) imposes standards to ensure that the management of sewerage infrastructure does not unduly cause adverse effects to the environment.

In south-east Queensland, there has recently been a major reform of the administration of water and sewerage networks through the *South-East Queensland Water (Restructuring) Act 2007* and the *South-East Queensland Water (Distribution and Retail Restructuring) Act 2009*. The latter Act created three separate council-owned 'distributor-retailers' that took over the management and operation of sewerage infrastructure and services from councils: UnityWater, which serves Moreton Bay and Sunshine Coast regions; Queensland Urban Utilities, which serves the Brisbane, Ipswich, Lockyer Valley, Scenic Rim and Somerset regions; and Allconnex which serves the Gold Coast, Logan and Redland City regions. (Gold Coast, Logan and Redland City councils will take back responsibility from Allconnex on 1 July 2012.) In all other areas the council is responsible for the management of sewerage infrastructure.

10.1.4 The impact of the 2010/2011 floods on sewerage infrastructure

The Commission received evidence that sewerage systems were affected in all areas where major flooding was experienced, and that, in many areas, there was a need to warn the public about the possible contamination of public areas and waterways by untreated sewage.

Damage to sewerage infrastructure managed by Queensland Urban Utilities

The Commission received detailed evidence from Queensland Urban Utilities about the impact of the 2010/2011 floods on its sewerage system, which serves approximately 1.25 million people.[3] Flooding affected 128 sewerage pump stations operated by Queensland Urban Utilities; they suffered varying levels of damage.[4] Nine sewage treatment plants were affected.[5] The principal damage caused by inundation was to the electrical systems (the generators and switchboards) resulting in critical failures of treatment systems[6] (see section *10.1.6 Electrical switchboards and generators* below).

The damage to infrastructure and the inundation of the sewerage system resulted in the discharge of untreated sewage through overflow relief structures, which are designed for this purpose, and backflow of sewage into private properties in the Brisbane area. (Overflow relief structures are discussed in section *10.1.7 Prevention of sewage discharge* below.) The Brisbane City Council issued a media release on 12 January 2011 notifying residents of the prospect that untreated sewage could enter floodwaters and of the risk this posed to human health.[7] The operations log and situation reports for the Brisbane local disaster co-ordination centre show that reports were received of untreated sewage entering waterways and of sewage leaks occurring near residential premises.[8] A situation report of 28 January 2011 identified 19 public parks as possibly contaminated with sewage.[9]

Queensland Urban Utilities' records show that between 11 January 2011 and 25 January 2011 it attended 110 locations to perform site clean-ups, in 65 of those cases responding to reports of 'sewerage flooding / backflow'.[10] (Because its focus was on cleaning up rather than identifying causes, it was unable to confirm whether all cases involved sewage flooding or backflow.[11]) To alleviate public health risks, the organisation used diesel pumps to collect untreated sewage, which was removed by tankers or discharged to waterways.[12] Queensland Urban Utilities' general manager for planning expressed the view that the likely causes of sewage flooding and backflow were the large volume of rain, the height of the floodwaters, the failure of sewerage infrastructure due to inundation and loss of electricity and, possibly, sewerage systems being overwhelmed by stormwater entering through illegal connections.[13]

The owner of an apartment in a multi-storey complex at West End described to the Commission how, during the 2010/2011 floods, dirty water, possibly sewage, rose into baths and toilets in the apartment complex. She suspected that it emanated from the sewerage system because the baths and toilets were not overtopped by floodwater.[14] Queensland Urban Utilities' general manager for planning said the organisation had not received any reports of sewage backflow or flooding at the building at the time, although it was aware of flooding in the general vicinity.[15] Investigations conducted by Queensland Urban Utilities later in 2011 indicated that sewage backflow in West End was caused by a number of factors, including debris in the sewer, a fracture in the cross-river sewerage pipeline that ran under the Brisbane River and the inundation of the Grey Street pump station.[16]

Damage experienced elsewhere in Queensland

The 2010/2011 floods caused significant damage to sewerage infrastructure throughout Queensland. Its repair was expensive, the loss of treatment facilities inconvenient and the releases of untreated sewage a cause of hardship and distress.

The director of infrastructure for the South Burnett Regional Council gave evidence of multiple sewer collapses and damage to sewage treatment plants in the Nanango and Kingaroy areas.[17] The cost of reconstruction of and repairs to the council's water supply and sewerage infrastructure exceeded $2 million.[18]

In the neighbouring area of North Burnett Regional Council, floodwaters damaged the sewerage pump stations and effluent holding tanks in Mundubbera, Gayndah and Monto. The sewerage system functioned satisfactorily until flooding reached a level which required removal of the control panels and electrical systems.[19] In Mundubbera, floodwater entered the sewerage system through flooded houses, causing an overload of the pump station, which was then shut down.[20] Untreated sewage was discharged into the river system from the Mundubbera and Gayndah pump stations, which had been shut down.[21] Eidsvold also experienced flooding, but it did not suffer the same damage to the sewerage infrastructure as occurred elsewhere in the North Burnett council region. The cost to the council of the reconstruction works required for the water and sewerage systems was around $2 million.[22]

In St George, in the Balonne region, steps were successfully taken to prevent inundation of the sewerage infrastructure. Sewerage pump stations were sandbagged and sewer entry points below previous flood levels were blocked to prevent floodwater causing backflow.[23]

At Theodore, in the Banana Shire, the sewerage pump station transmitting sewage to the township's sewage treatment plant was flooded. Ergon Energy shut off power to it on the morning of 27 December 2010, preventing further pumping to the treatment plant.[24] By the afternoon of that day, reports were being received of backflow through the sewerage system.[25] In Jericho and Alpha, within the Barcaldine Regional Council area, a number of septic tanks were submerged in floodwater. Following the flooding, sewage pumping trucks were used to pump the tanks out.[26]

In Bundaberg, the sewage treatment plants at Millbank and East Bundaberg were disabled by the council's removal of the plants' electrical systems in anticipation of the inundation which subsequently occurred. Because the sewerage network as a whole is gravity driven, even without a functioning electrical system it continued to deliver sewage to the treatment plants, with the result that untreated sewage was discharged into the waterways. These discharges were heavily diluted; only a negligible impact on the environment was identified.[27] Although the removal of the electrical systems disabled the plants, it meant that systems could be restored more efficiently once the floods subsided.[28] There were also concerns about the malfunctioning of private septic systems: a resident of Gooburrum gave evidence that the floodwaters near his house were declared contaminated because the contents of underground septic tanks had leached into the water.[29] He also said that his neighbour's septic tank had floated up out of the ground.[30]

In the Western Downs, the sewerage systems in Chinchilla and Dalby were affected by flooding, but no major damage was sustained. Sewerage services continued to operate throughout the floods in Chinchilla, despite the main pump station's being located in the flooded area of the town.[31] In Dalby the sewerage network was inundated, although full treatment was restored shortly after the floods receded.[32]

In Kilkivan, effluent ponds forming part of the sewage treatment plant flooded and overtopped.[33] The director of engineering at Gympie Regional Council said that the council investigated claims that effluent may have entered residential premises, but concluded that it had not, and that no harm had been suffered from the overtopping.[34] An SES officer from Kilkivan gave evidence that some houses in Kilkivan were flooded by sewage or effluent, including one located only 500 metres from the sewage treatment plant; but he acknowledged that it was not clear whether the source of the waste in that house was the sewage treatment plant or private septic systems.[35] One of the houses he identified was ultimately condemned, at least in part because of evidence that sewage had entered the house.[36]

The chief executive officer of UnityWater, the distributor-retailer that provides sewerage services for the Moreton Bay Regional Council and the Sunshine Coast Regional Council, gave evidence that almost $1 million in damage was suffered to the sewerage systems of Maroochydore, South Buderim, Caloundra (Golden Beach and Dicky Beach), Kallangur, Brendale and Murrumba Downs.[37]

In the Southern Downs, the Stanthorpe sewage treatment plant was inundated by floodwaters.[38]

In Emerald, 19 of the 30 sewerage pump stations were inundated by floodwater; of those, seven suffered electrical damage as a result of their control panels or switchboards being submerged. The 12 pump stations that did not suffer electrical damage were able to return to service once the floodwaters subsided.[39] In Rolleston, two pump stations were flooded and suffered electrical damage.[40]

10.1.5 The location and design of public sewerage infrastructure

The location of public sewerage infrastructure

The location of the plant and infrastructure in public sewerage systems is constrained by a number of factors, which in combination often lead to the location of public sewerage systems in areas susceptible to flooding.

Sewage treatment plants have to be located within reasonable proximity of the communities that they serve. The distance from the point of collection of sewage to the location of its treatment must be minimised, because sewage degrades when it travels over distance, affecting its treatability.[41] (At the same time, of course, a buffer between residential areas and sewage treatment plants is desirable.[42]) Additional limiting factors include the need to allow access for maintenance and the need to allow for the location of other infrastructure, such as stormwater systems and underground power cables.[43]

Most sewerage infrastructure networks are driven by gravity and are designed to make use of the gradient of the land. Although alternative systems (such as pressurised sewerage systems) exist, gravity based systems are the most cost effective because of their relatively low power consumption and pumping costs. As a result, sewerage systems are usually designed to drain to the lowest point of the natural land layout and sewage treatment plants are typically located on low lying land.[44] Treatment plants require discharge points for the release of treated sewage and, in an emergency, of untreated sewage, which means that they are usually positioned adjacent to waterways, such as rivers or creeks.[45] In consequence, the natural site for a sewage treatment plant will often be on low lying land near a waterway, which may be susceptible to flooding.

State Planning Policy 1/03 imposes particular development outcomes on development within 'natural hazard management areas', which includes areas identified as likely to be inundated during a 'Defined Flood Event'. There is a specific development outcome that '[e]ssential services infrastructure (e.g. on-site electricity, gas, water supply, sewerage and telecommunications) maintains its function during a [defined flood event]'.[46] The 'Defined Flood Event' is determined for each area by the relevant council, but is typically identified by reference to the 1% AEP flood.[47] It does not necessarily encompass all land that might, at some time, flood. This development outcome is not mandatory and can be departed from where there is an overriding need in the public interest or in order to satisfy a development commitment.[48] Whether an overriding need exists depends on an assessment of the net economic, social and environmental benefits to the community and the likelihood of suitable alternative sites being available.[49]

State Planning Policy 1/03 applies where a natural hazard area for flood has been identified, unless a local planning instrument has been recognised as compliant with it, in which case the local planning instrument applies.

For example, Bundaberg Regional Council has jurisdiction over four legacy planning schemes from pre-amalgamation councils. Codes within three of them - the Bundaberg City Flood Management Code,[50] the Burnett Shire Natural Features or Resources Overlays Code,[51] and the Isis Shire Residential Zone Code[52] - contain provisions about the protection of sewerage infrastructure from flooding similar to those in State Planning Policy 1/03, whereas in Kolan Shire, there are no provisions.[53]

Queensland Urban Utilities gave evidence that, during the planning stage for sewerage infrastructure, consideration is given to flood risk, including the proposed site's history of flooding, hydrological site assessments, Q100 levels, flood models and the resilience of the proposed infrastructure to flooding.[54] These factors are weighed against engineering and commercial considerations.

UnityWater explained that the design manuals applicable to its area of operation specify various flood resilience parameters for sewerage pump station wet wells and switchboards. It noted that the level to which sewage treatment plants should be built is not specified, but that all of its sewage treatment plants are located above the 1% AEP flood level.[55]

The North Burnett Council, which had a number of pumping stations affected by flood, is in the process of lifting low-lying pumping stations to higher elevations to improve their flood resilience. The director of technical services for the North Burnett Regional Council noted that even after such changes are made, pumping stations remain vulnerable to being overwhelmed by the entry of water into the sewerage system through flooded homes.[56]

The evidence does not lead the Commission to conclude that there is a need for any fundamental reconsideration of the location of sewerage infrastructure to reduce its flood susceptibility. The approach taken in State Planning Policy 1/03 appears sound. However, in light of the reality that many sewage treatment plants are located in areas susceptible to flooding, improving resilience through design of the infrastructure is important.

The design of sewerage infrastructure

The Department of Environment and Resource Management (DERM) Planning Guidelines for Water Supply and Sewerage, prepared by the Queensland Government to assist in strategic planning for water and sewerage,[57] provide guidance on process and principles, rather than specific technical requirements. The general manager for Queensland Urban Utilities gave evidence that it had a general rule of operating within the guidelines, but found them in some instances impractical. He noted, as an example, that section 5.2.2 of chapter 5 of the guidelines suggested the peak wet weather flow in a sewer could be modelled as five times the average dry weather flow; whereas Queensland Urban Utilities experienced up to thirty times the average dry weather flow through its network during extreme weather events.[58] The representative of one regional council indicated that it had moved from reliance on the guidelines to use of the Water Services Association of Australia Codes, an industry publication.[59]

Queensland Urban Utilities has adopted a formal sewer overflow mitigation strategy (developed by reference to industry guidelines, including the DERM guidelines)[60] as part of its strategic asset management plan. One component of the strategy is to identify areas that are at risk of sewage flooding or backflow to allow the authority to direct its infrastructure upgrade, maintenance and education campaigns to those vulnerable areas and to track sewage flows more closely. It has a case management approach for properties that are particularly susceptible to sewage flooding or backflow (as identified from a history of past complaints, the condition of the sewerage system, and hydraulic models of the sewerage system)[61] to ensure they are given priority.[62]

Queensland Urban Utilities' sewerage network has been constructed with reserve capacity to allow it to continue to function in the event of failure of one part of the system. For example, it has storage areas for sewage and back-up generators for the event of power failure.[63] The network has overflow relief structures built into it which, in emergency situations, discharge sewage into local watercourses to prevent discharges in residential areas.[64] Pump stations are typically designed to include submersible pumps and motors that are not affected by floods. Electrical control panels are elevated, to some extent, to minimise the risk from flooding.[65]

UnityWater adverts to similar matters to those considered by Queensland Urban Utilities in the design and management of sewers. The chief executive officer explained that the requirement that all sewers are built to at least five times the average dry weather flow allows for the inevitability that there will be defects and openings in any sewer through which stormwater runoff and groundwater can enter.[66] Standards are applied in the design of certain components of the sewer network, such as a requirement that sewerage pumping station wet walls must be finished 300 millimetres above the level of the flood with an average recurrence interval of 20 years.[67] Sewers must be a minimum of 150 millimetres in diameter to minimise blockages.[68] The chief executive officer explained that UnityWater uses hydraulic models to model sewage flows to identify areas that may need to be reinforced, and it is presently installing a supervisory control and data acquisition system that will allow it to monitor and control pumping stations remotely.[69]

The flood resilience of the sewerage network can be improved by sealing, or by sealing and pressurising, the sewerage pipe network to prevent stormwater or floodwater entering the network.[70] Sealed systems comprise pipes and maintenance shafts with welded joints to prevent stormwater or tree roots entering the system.[71] A pressure system is operated by a pumping unit located on each property, rather than by gravity. The pump requires power to operate and is therefore an increased cost to the property owner.[72] Queensland Urban Utilities suggested that the Australian Building Codes Board standard presently being developed should include a requirement that all new developments have sealed sewers and all new developments in areas that are susceptible to flood have sealed and pressurised sewers.[73] The Commission has not received detailed evidence on the advantages and disadvantages of these systems and is not a position to make a finding as to whether the Australian Building Codes Board standard should contain such a requirement.

Queensland Urban Utilities pointed out that its ability to take control over the design of sewerage infrastructure was limited by the fact that it has no role in planning decisions such as the location of new property developments. It is simply obliged to provide sewerage infrastructure for whatever is planned or developed,[74] although it does act as a referral agency for major developments and thus has a role in assessing those development applications.[75] A further limitation is that property owners are responsible for all sewerage systems and plumbing to the boundary of their property, over which the authority has no control.[76] Queensland Urban Utilities suggested that there may be advantages to allowing it greater involvement in planning processes and the setting of development conditions through more direct engagement between it and councils.[77]

Queensland Urban Utilities' suggestion has merit: there are obvious benefits to ensuring that planning and development decisions that affect sewerage infrastructure are made in consultation with the authority responsible for the management of that infrastructure. However, there are a number of ways in which that might be achieved and it is unnecessary for this Commission to select a mechanism. The Queensland Government intends to conduct a review, due to be completed by July 2013, of the planning and development assessment arrangements across the south-east Queensland region to determine the role of distributor-retailers in land use and infrastructure decision-making processes.[78]

As noted above, evidence was received that floodwater may have been contaminated by sewage leaking from private on-site sewerage systems, such as septic tanks. The Commission did not receive detailed submissions on the adequacy of the design standards applicable to private on-site sewerage systems. Relevant standards are set out in the Queensland Plumbing and Wastewater Code, which provides acceptable performance solutions to meet the statutory requirements of the *Plumbing and Drainage Act*.[79] Flood resilience is not a specific performance criterion and is not mentioned in the code at all. It appears to the Commission that this is a matter that it would be prudent for the Queensland Government to consider for inclusion as a performance criterion.

Recommendation

10.1 The Queensland Government should consider including in the criteria in the Queensland Plumbing and Wastewater Code a requirement that the risk of leakage from private on-site sewerage systems during floods be minimised.

10.1.6 Electrical switchboards and generators

The main damage to sewerage infrastructure during the 2010/2011 floods was to the electrical switchboards and generators, which are not designed to withstand submersion in water.[80] The other principal components of the system, for example pumps, are typically designed to be submersible and are not affected by inundation (although they are vulnerable to impact damage, and some parts are susceptible to power outages).

Damage to the switchboards and generators resulted in critical failures to treatment systems. This infrastructure is vital to the operation of the system as a whole; its susceptibility to inundation determines whether the sewerage system can function during a flood, and it affects the length of time required for the system to become operational again after a flood.

The State Planning Policy 1/03 Guideline provides suggested solutions to achieve the planning outcome that sewerage infrastructure must continue to function during a Defined Flood Event (DFE).[81] It proposes, relevantly, that any components of the infrastructure that are likely to fail to function or may result in contamination when inundated by floodwater (for example, electrical switchgear and motors) are '(a) located above the DFE; or (b) designed and constructed to exclude floodwater intrusion/infiltration'.[82]

Queensland Urban Utilities' chief operating officer gave evidence that, where practical, critical electrical and mechanical infrastructure is located at elevated levels within the sewerage system.[83] He observed that in existing infrastructure this is not necessarily above the Q100 level.[84] Following the 2010/2011 floods, Queensland Urban Utilities considered moving switchboards in sewage treatment plants to above the Q100 level, but preferred, given the considerable design and site works that would have been involved, to focus on restoring operational infrastructure to its pre-flood condition.[85]

UnityWater gave evidence that its understanding of the combined effect of the Queensland Government guidelines and the design manuals of the councils within its jurisdiction was that sewerage pumping station switchboards must be located one metre above the level of the flood with an average recurrence interval of 50 years.[86]

Queensland Urban Utilities is reassessing the appropriate positioning of electrical systems in new infrastructure, and has commissioned consultants to reassess new infrastructure being built in an upgrade of the Fernvale and Lockyer Valley sewage treatment plants.[87] It has also commissioned a firm of consulting engineers to undertake a study of the resilience of its existing infrastructure, including the electrical systems, against future floods.[88] In advance of this study's being finalised, Queensland Urban Utilities has relocated to higher ground a major power generator at Oxley Creek sewage treatment plant, which was flooded in the 2010/2011 floods.[89]

The general manager for planning for Queensland Urban Utilities suggested that in all new developments in areas susceptible to flooding there should be a requirement that, subject to funding constraints, critical infrastructure should be located above peak maximum flood levels.[90] The Commission has not received detailed evidence on the relative costs, advantages and disadvantages of mandating that critical infrastructure is always located above a prescribed flood level, whether that be 1% AEP flood, highest historical flood or probable maximum flood level. (Certainly the last seems an over-cautious approach.) It may be that in certain locations the cost of designing and constructing a sewage treatment plant with elevated critical infrastructure is disproportionate to the benefits to be obtained. The Commission considers it desirable that relevant authorities undertake risk and cost/benefit analyses of upgrading existing infrastructure where there have been significant adverse effects from flooding on the infrastructure and, in consequence, on the community. When resources allow, the review of other infrastructure to determine whether it should be upgraded would be desirable; priority should be given to areas that are most vulnerable to inundation.

Recommendations

10.2 Authorities responsible for the construction of sewerage infrastructure should, when embarking on new works, undertake risk and cost/benefit assessments to determine the level at which electrical infrastructure that may be vulnerable to inundation should be placed.

10.3 Authorities responsible for the management of sewerage infrastructure should conduct a review of their existing infrastructure to identify electrical infrastructure that may be vulnerable to inundation and perform risk and cost/benefit assessments to determine if it should be relocated to a higher level.

10.1.7 Prevention of sewage discharge

When the sewerage system becomes overwhelmed, untreated sewage sometimes discharges through household drains and toilet pedestals.[91] In general, such discharges are a greater danger to human health than sewage contaminated floodwater because they are undiluted.[92] A number of mechanisms can be installed within the sewerage system to mitigate or prevent these discharges: overflow relief structures, overflow relief gully grates and sewage reflux valves.

Overflow relief structures

Overflow relief structures are built as part of the public sewerage system to provide an outlet for sewage to discharge in emergency situations or in extreme weather events. They are pipes designed to discharge the untreated sewage into a waterway; while undesirable, this is preferable to discharging to residential or commercial properties. As already described, these overflow relief structures discharged untreated sewage into waterways in Brisbane during the 2010/2011 floods.

Overflow relief structures are typically located adjacent to waterways[93] or in other locations where the discharge will have a minimal effect on people and the environment and the discharge can be cleaned up efficiently.[94] However, when the levels of waterways are elevated, overflow relief structures near waterways may become submerged and incapable of discharging excess sewage from the overloaded system. The increase in water pressure throughout the sewerage network may then result in backflow, lifting manhole covers and causing localised flooding elsewhere in the system. Manhole covers can be secured to ensure that this does not occur, although there is the possibility that this may in turn cause backflow into residential ground floor facilities through shower grates and toilet pedestals.[95] Overflow relief structures, therefore, cannot be relied on to provide complete protection against sewage discharges during extreme weather events.

Overflow relief gully grates

Overflow relief gully grates are small grates located on residential premises within the private property boundary. They are connected to the sewerage system and have an opening at a lower height than the lowest bathroom or kitchen fixture within the premises. Their purpose is to ensure that if there is any backflow into the private sewer system, the discharge will occur through the overflow relief gully grate outside the house rather than through the bathroom or kitchen fixtures.[96]

Overflow relief gully grates cease to function if the level of stormwater or floodwater rises above the height of the grate outlet; at this point they become an entry point for stormwater into the sewerage system. Queensland Urban Utilities intends to trial different designs for overflow relief gully caps to prevent stormwater entering the grates:[97] a welcome initiative. The problems caused by the entry of stormwater into the sewerage system are discussed further at *10.1.8 Illegal connections of stormwater to sewerage infrastructure* below.

Recommendation

10.4 Queensland Urban Utilities should make the results of its trials on the use of caps for overflow relief gully grates available to other authorities responsible for sewerage infrastructure. Consideration should be given by those authorities as to how the results can be used to improve the flood resilience of their sewerage networks.

Sewage reflux valves

Sewage reflux valves, also known as backflow preventers, are devices that can be installed in household sewerage systems. They act as one-way valves to prevent the backflow of sewage into private sewer systems and then into bathroom or kitchen fixtures. Under current arrangements, it is up to house owners whether or not they install sewage reflux valves at their properties. Queensland Urban Utilities considers that householders are typically reluctant to install these valves because they may preclude the use of toilets and showers during floods, since when in operation they prevent waste from being discharged from the property.[98] Another cause of reluctance is that, since the backflow preventers are located on private premises, their maintenance is the responsibility of the landowners rather than a public authority.[99]

In some locations, a variant of a sewage reflux valve known as a gate valve is used. These are manually operated valves that require comparatively less maintenance.[100] Backflow can also be prevented through the use of sealed and pressurised sewers on private property.[101]

On 2 February 2011, Building Codes Queensland presented a paper to the Plumbing Industry Council that outlined its concerns that sewage infiltration from sewerage mains caused significant damage to properties that were not inundated with floodwater in the 2010/2011 floods. It stated that overflow relief gullies failed to provide adequate protection and recommended that properties in low-lying areas subject to flooding should install reflux valves at the boundary connections to prevent surcharge from sewer mains.[102] No proposal was made to amend legislation to make such installations mandatory, because the matter was being reviewed by councils.[103]

Subsequently, a proposed new part of the Queensland Development Code has included a requirement imposing new standards for the prevention of sewage reflux through the mandatory installation of sewage reflux valves in new buildings in designated flood hazard areas.[104] The proposed new part of the code requires that the sanitary drain for a building be protected from backflow by fitting a reflux valve for sewage between the building and the point of connection to the public sewerage infrastructure. The installed reflux valve should be accessible for maintenance.[105]

Councils generally support the inclusion of reflux valves as a mandatory part of the Queensland Development Code, noting, however, that the valves can fail if not maintained properly.[106] The Building Services Authority has also noted that reflux valves are not always effective.[107] An independent engineering consultant engaged by the Commission commented that while reflux valves are effective in preventing backflow during floods, because they are prone to blockage and may increase head losses, they should only be used where sewage backflow is likely to occur.[108] The maintenance of reflux valves is an issue that lends itself to the development of guidance material, particularly where responsibility for maintenance falls upon the homeowner. Should the Queensland Development Code include mandatory provisions related to the installation of reflux valves, the Queensland Government should develop appropriate advisory material for homeowners.

It is uncontroversial that mitigating the risk of sewage reflux and improving flood resilience of the sewerage infrastructure are desirable outcomes and that, at least in some circumstances, the installation of sewage reflux valves assists in achieving them. However, the Commission has not received detailed evidence on the relative advantages and disadvantages of these valves in all situations. It is not, therefore, in a position to reach a conclusion on the merits of including in the Queensland Development Code a requirement for the mandatory fitting of sewage reflux valves. (See section *9.5 Proposed new part of the Queensland Development Code: 'Construction of buildings in flood hazard areas'* for further discussion of the Queensland Development Code.)

Recommendation

10.5 If the Queensland Development Code is amended to include provisions requiring homeowners to install sewage reflux valves, the Queensland Government should develop and make available to homeowners appropriate guidance material to assist them in meeting their responsibilities to maintain reflux valves.

10.1.8 Illegal connections of stormwater to sewerage infrastructure

The sewerage and stormwater systems serve different purposes. The stormwater system manages rainfall, whereas the sewerage system is designed to collect and transfer human waste to sewage treatment plants.[109] The sewerage system is not designed to convey significant quantities of stormwater or floodwater and may be overwhelmed if large volumes of either enter the system.[110] If the sewerage system's capacity is exceeded, untreated sewage will be directed into waterways through overflow relief structures.[111]

The discharge of stormwater into the sewerage system is prohibited under section 193 of the *Water Supply (Safety and Reliability) Act*. Notwithstanding this, the chief operating officer of Queensland Urban Utilities described the practice of property owners directing a downpipe from a building's roof into the sewer overflow grate as 'quite common'.[112] That conclusion was drawn in part from the dramatic increase in the volume of flow experienced through Queensland Urban Utilities' system during exceptional weather events[113] (although such flows could also be caused by stormwater entering broken sewerage pipes or by the inundation of inlets or outlets).[114] It is also based on the results of what Queensland Urban Utilities general manager of planning described as 'smoke testing': the introduction of smoke into the sewerage system so that the smoke will then rise through the sewers and emit from the gutters of houses that have stormwater pipes connected to the sewerage system.[115] Queensland Urban Utilities expressed its concern that homeowners connecting their stormwater systems to the sewerage system may have contributed to the sewerage system's being overwhelmed in the 2010/2011 floods.[116] UnityWater also identified the existence of illegal connections; when it conducted surveys of the areas for which it is responsible, it found that between 5 and 10 per cent of properties surveyed had illegal connections.[117]

The Brisbane City Council has a different view of the prevalence of such illegal connections: during the December 2010/January 2011 period it recorded only seven cases in which stormwater drainage systems were illegally connected to sewerage systems, six of them related to connections to private sewerage drainage systems rather than to Queensland Urban Utilities' infrastructure.[118] Only four more instances were investigated in the intervening period to November 2011.[119] Brisbane City Council regards the impact of illegal stormwater connections to sewerage infrastructure as perhaps 'overstated', having regard to the low incidence of illegal connections and the relatively low volume of stormwater entering the sewerage infrastructure through illegal connections where they occur.[120]

The divergence of views between Queensland Urban Utilities and the Brisbane City Council as to the proportions of the problem of illegal connections may arise from a difference in approach to analysis of the issue: Brisbane City Council points to the rates of enforcement, whereas Queensland Urban Utilities focuses on the number of probable illegal connections it has identified through flow analysis and smoke testing, without enforcement action. Another possibility is that the issue of illegal stormwater connections is not as significant in Brisbane as elsewhere in Queensland Urban Utilities' area of operation. The Commission has not received evidence on this point from the other councils in areas Queensland Urban Utilities serves.

Illegal connections are not the only means by which stormwater enters the sewerage system; for example, it may enter through uncapped sewerage relief gully grates. The DERM Planning Guidelines for Water Supply and Sewerage specifically incorporate 'unauthorised roof, ground or stormwater drainage' as a component in determining 'peak wet weather flow', a value used in calculating the minimum capacity of the sewerage system.[121] That recognition suggests that the problem of illegal stormwater connections should be considered by sewer designers and an allowance made for a degree of surplus capacity to accommodate it.

Up until July 2010, councils were responsible for the sewerage networks and still retain that responsibility outside of south-east Queensland. A prohibition on connections of stormwater to sewerage infrastructure is imposed by, and associated enforcement powers are granted to councils under, the *Plumbing and Drainage Act*, the *Standard Plumbing and Drainage Regulation 2002*, the *Sustainable Planning Act*, *Local Government Act* and, in the case of the Brisbane City Council, the *City of Brisbane Act*. The councils' enforcement powers under the *Plumbing and Drainage Act* include the power to issue written notices to the owners of premises with illegal drainage or to the person who performed the plumbing or drainage work requiring the recipient to do such things as may be stated in the notice:[122] typically, to rectify the illegal connection.[123] Similar powers are conferred by the *Local Government Act* and the *City of Brisbane Act*.[124] All three pieces of legislation empower council representatives to enter private property with the occupier's permission or with a warrant.[125] Councils do not have a regulatory or enforcement role under the *Water Supply (Safety and Reliability) Act*,[126] but, in the view of the Brisbane City Council, their existing powers under legislation are adequate to prevent, and order rectification of, illegal connections.[127]

The enforcement and investigation powers vested in the councils have not been transferred to the distributor-retailers, despite the transfer of responsibility for water and sewerage services.[128] A distributor-retailer may enter 'places' for the purpose of repairing its own infrastructure,[129] but not for the purpose of identifying illegal connections of stormwater pipes to the sewerage system and, in any event, not into parts of 'places' used for residential purposes.[130] Nor can it compel the disconnection of such connections.

Queensland Urban Utilities' present practice is that when it identifies a suspected illegal connection, it reports the matter to the relevant council, which is then responsible for inspecting the property or otherwise dealing with the private property owner.[131] However, Queensland Urban Utilities submitted that the councils' use of powers was directed primarily towards stormwater management, and ensuring sewerage discharges did not enter the stormwater system, rather than the converse.[132] When smoke testing of properties is conducted, Queensland Urban Utilities personnel attend sites together with personnel from the council responsible for that area.[133] Queensland Urban Utilities described the level of co-operation between it and its participating councils as 'very good', but it suggested that it was an inefficient use of resources to have personnel from both the distributor-retailer and the relevant council present when investigating illegal stormwater connections.[134] In Queensland Urban Utilities' view, the current regulatory framework is inadequate.

Queensland Urban Utilities submitted that stormwater flows within the sewerage system could be effectively reduced through two measures. First, it proposed increased community and industry education on the need to maintain separate sewerage and stormwater systems and the importance of not connecting stormwater systems to the sewerage systems; some property owners may not be aware that the systems are separate or may not appreciate the importance of the separation.[135] Second, it suggested an extension of the statutory powers of distributor-retailers like Queensland Urban Utilities under the *Water Supply (Safety and Reliability) Act* to allow them to investigate whether illegal stormwater connections exist on private properties and, if so, to require their removal.[136] UnityWater and Ipswich City Council made similar submissions to the Commission.[137] Another proposal was for a statutory requirement that any house to be sold be subject to inspection of its stormwater connections prior to sale.[138] If all else failed, 'enhanced' sewer planning in areas prone to flooding or stormwater flow might need to be considered.[139]

The Commission is not in a position to make findings about the extent to which illegal connection of stormwater pipes to sewerage infrastructure causes sewerage flooding. However, it seems clear that illegal connections do occur and, if allowed to go unchecked, have the potential to affect adversely the ability of the sewerage system to withstand extreme weather events. There seems, also, to be a gap in the practical workings of the enforcement regime applicable to illegal stormwater connections. However, the Commission is unconvinced that the remedy is to extend powers of entry or enforcement to an additional group of entities. The distributor-retailers have the technological capability to detect illegal connections of stormwater to sewage infrastructure. The better course is for them to work with councils, providing evidence for enforcement action, with a mutual exchange of information.

Recommendations

10.6 Queensland Urban Utilities, and other distributor-retailers and councils, that have identified a practice of stormwater drains being connected to sewerage infrastructure, should conduct a program of education to raise public awareness that this practice is illegal and impedes the operation of the sewerage infrastructure.

10.7 Councils and distributor-retailers should agree to protocols for the exchange of information about suspected illegal connections, the steps being taken to investigate them or the basis for concluding that no investigation is required, and the results of any investigations or enforcement actions.

10.1.9 Interactions with disaster management groups

Queensland Urban Utilities raised a concern that, despite its role as a provider of essential services in contact with the public, as users of sewerage services, it did not have any direct involvement with or line of communication to the state disaster management group during the 2010/2011 floods.[140] Instead, the state disaster management group engaged with the SEQ Water Grid Manager.[141] Queensland Urban Utilities pointed out that while the SEQ Water Grid Manager undoubtedly has an important role to play in disaster management, unlike Queensland Urban Utilities it has no responsibility for sewerage and does not interact directly with the end users of sewerage services.[142]

That concern would appear to be met by 48A of the *Disaster Management Act 2003* (inserted into the Act by the *Disaster Readiness Amendment Act 2011*) which requires disaster management groups to consult with providers of essential services, such as sewerage infrastructure, if the chairperson of the disaster management group considers that the provider can assist the group. Disaster management groups are defined in the *Disaster Management Act* to include state, district and local groups.[143]

For the reasons outlined by Queensland Urban Utilities, it is likely that in many disaster situations, particularly major floods, Queensland Urban Utilities and other distributor-retailers will be well-placed to assist the relevant disaster management group.

10.2 Stormwater

10.2.1 Overview of the stormwater network

The role of the stormwater network

Stormwater is rain water that has not yet entered a river system or soaked into the ground. The aim of the stormwater network is to ensure that stormwater flows generated from developed catchments cause minimal nuisance, danger and damage to people, property and the environment.[144] Those parts of the stormwater system that are used primarily to manage the quality of the water, rather than its flow,[145] are not considered in this report.

The stormwater network comprises:

a. stormwater infrastructure, which is the civil works built for the primary purpose of stormwater collection and conveyance, such as pipes, gullies, inlets and culverts

b. natural components such as overland flow paths and waterways.[146]

In Australia, stormwater and sewerage networks are designed to operate separately: the stormwater network is not designed to process human waste, and sewerage networks do not have the capacity to carry the volume of flows caused by stormwater.[147] The problem of stormwater infiltration into the sewerage system is discussed in section *10.1 Sewage and sewerage*.

The stormwater network provides some flood mitigation benefits, but is not designed to manage major creek or river flooding.[148] If the stormwater network is poorly designed or poorly maintained it may provide only limited flood mitigation benefits. Areas with old stormwater networks constructed for smaller populations than those they now serve, or built to outdated design standards, are flooded more frequently by stormwater than areas with modern networks.[149]

Stormwater contributed to flooding in many locations in the 2010/2011 floods, sometimes in combination with riverine flooding. There are two particular types of stormwater flooding which will be dealt with in some detail in this section: flooding of basements by stormwater, which is discussed in section *10.2.4 Basements*, and flooding by stormwater by backflow through the pipe network, which is discussed in section *10.2.6 Backflow flooding*. The latter type of flooding was especially a problem in low-lying areas of Brisbane, occurring even before the banks of the river had been breached.

The components of stormwater networks

Stormwater pipes are pipes designed for the purpose of collecting and conveying stormwater. They include both stormwater drains and secondary pipes that link gullies and inlets to the stormwater drains.[150] Stormwater pipes are often located underground.

Gullies and inlets are entry points for stormwater to enter stormwater pipes. The term ‘gully’ usually refers to a grilled box inlet of the type commonly seen in suburban streets. ‘Inlets’ are usually openings in parks or open areas.[151]

Kerbs and channels (or gutters) are the structures built on the sides of roads that allow the road surface to convey water flow.[152]

Culverts are short passageways under roads designed to allow stormwater to flow from one side of the road to the other without being dammed by the roadway.[153]

Detention basins are depressions in the ground constructed for the purpose of catching and holding stormwater. The captured water is then drained out gradually by a pipe, so that the release has a reduced impact, compared to its effect if the same volume of water flowed uncontrolled during a large inundation.[154]

A backflow prevention device is a one-way valve installed at, or near, the point at which a stormwater pipe discharges into a waterway. The purpose of the device is to ensure that, if the water levels rise in the waterway, water does not flow back through the stormwater network and flood low-lying areas.[155] Backflow prevention devices are discussed in more detail at section *10.2.6 Backflow flooding* below.

The other key components of the stormwater network are waterways and overland flow paths.[156] In each case they may be naturally occurring or partially or totally constructed.[157] Waterways include creeks, rivers and wetlands. Overland flow paths are depressions in the ground in which water accumulates and then flows.[158]

10.2.2 The regulatory structure applicable to stormwater networks

A number of pieces of legislation regulate stormwater infrastructure.

The *Sustainable Planning Act 2009* provides the planning framework for managing the process by which development takes place, which includes carrying out plumbing and drainage work. All new work may be subject to development assessment.

The *Plumbing and Drainage Act 2002* establishes the legislative framework for plumbing and drainage work. It requires that stormwater drainage be kept separate from sewerage infrastructure.

The *Building Act 1975* requires that stormwater drainage be taken into account in building development approvals and stormwater runoff considered in building work undertaken in areas susceptible to erosion.

The *Local Government Act 2009* and the *City of Brisbane Act 2010* prohibit the connection of any part of the sewerage system to the stormwater system and give councils the power to take enforcement action to rectify illegal connections.

The *Environmental Protection Act 1994* (with related legislation) imposes standards to ensure that the management of stormwater and drainage does not cause undue adverse effects to the environment. The *Environmental Protection (Water) Policy 2009* requires councils to develop and implement urban stormwater quality management plans to manage the quality of urban stormwater flows.

10.2.3 The design and construction of stormwater networks

Design principles

The stormwater network has a role to play in flood mitigation; however, it is not constructed to manage major river or creek flooding.[159] As with any infrastructure, stormwater infrastructure is only effective up to its design limits. Stormwater design standards aim to strike a balance between managing risk and the cost to the community, rather than to provide immunity from all stormwater flows.[160] For example, the underground pipe network is constructed to cope with stormwater from a storm with an average recurrence interval of 2 years to a storm with an average recurrence interval of 10 years;[161] its capacity will be exceeded during major inundations.[162] While it may be possible to build the network to accommodate rarer floods, for example to cope with a storm with an average recurrence interval of 100 years, this would involve higher capital and maintenance costs and is generally not economically feasible.[163]

Urban stormwater drainage systems are generally designed on a minor/major storm basis. The piped drainage system is designed to manage frequent minor storms of low severity, while the system of overland flow paths caters for severe storms which exceed the piped system.[164] Most stormwater flooding problems are caused by the inadequate capacity of one of these systems.[165] This is particularly an issue in older areas of cities and towns, where urban stormwater systems were designed before the advent of modern runoff and overland flow path practices.[166]

Councils are responsible for managing and enforcing compliance with stormwater standards in their respective jurisdictions through the design standards and development codes they administer.[167] The only stormwater infrastructure managed directly by the Queensland Government is that relating to state owned roads, for which the Department of Transport and Main Roads is the responsible authority.[168]

The Queensland Urban Drainage Manual is a stormwater planning and design guide produced by DERM in collaboration with councils and industry representatives.[169] The last edition was prepared in 2007. The manual is not mandatory, but it is used as a benchmark by councils to develop their own stormwater policies and standards.[170] Its contents are widely accepted and implemented by councils across Queensland.[171] The Queensland Development Code also sets out model standards for stormwater drainage for use by councils; however, they do not have any legislative force and are only advisory in nature.[172] (See section *9.5 Proposed new part of the Queensland Development Code: 'Construction of buildings in flood hazard areas'* for a more detailed discussion of the Queensland Development Code.)

Stormwater infrastructure is most efficiently installed contemporaneously with other development. Careful attention to stormwater drainage systems when they are built is essential; upgrades of inadequate systems can be very expensive, and may be impossible.[173] In designing new stormwater infrastructure it is important to consider both its local effect and its effect on the network, to ensure it does not exacerbate flooding locally or in other areas. In the land planning process, it is the responsibility of the developer not to increase the runoff downstream of the development.[174] For example, where land is built up with fill prior to the construction of a new development, care should be taken that there are no impacts by way of ponding or runoff to adjoining properties.[175] (See section *7.6 Placement of fill and development in a floodplain.*)

Stormwater design policies and standards, such as those set out in the Queensland Urban Drainage Manual, apply to new development.[176] They do not require that existing infrastructure be upgraded to meet the standards.

The Queensland Urban Drainage Manual specifies that the minor drainage system, which includes the underground drainage systems, should be built with sufficient capacity to convey flows from minor storm events in a way that does not pose a risk to pedestrians;[177] some inundation of the roadways is permitted.[178] A minor storm is one that has an average recurrence interval of between 2 and 10 years; which recurrence interval within that range applies depends on the level of urbanisation.[179] Some older stormwater networks, such as some of those in Brisbane and Ipswich, do not meet this standard.[180] The upgrade and optimisation of existing networks is considered further in section *10.2.5 The maintenance and optimisation of stormwater systems*.

The needs of stormwater networks differ across Queensland depending on factors such as topography, climatic conditions, the size of the catchment and the level of development of each location.[181] The financial capacity of each council will affect its ability to maintain and upgrade the stormwater networks under its control.[182] Parts of the stormwater network are also significant for other council functions, such as road construction, and other parts perform dual functions, such as parklands that operate as overland flow paths.[183] It is therefore appropriate that the design of stormwater systems is managed by councils, by reference to state and national policy; no evidence was presented to the Commission suggesting this should not be the case. However, the guidance materials, particularly the Queensland Urban Drainage Manual, are important resources for councils, helping to ensure that a common approach is taken across catchments that encompass multiple councils. These materials need, therefore, to be kept up to date by the responsible state-level authorities. The last edition of the Queensland Urban Drainage Manual was published in 2007 and it no longer reflects all current legislation; for example, the list of key legislation refers to the *Integrated Planning Act 1997* rather than the *Sustainable Planning Act 2009*.[184] It would be useful for the manual to be reviewed to ascertain whether any parts of it need to be amended, to reflect the current law and to take into account insights gained from the 2010/2011 floods.

Recommendation

10.8 The Department of Environment and Resource Management should review the Queensland Urban Drainage Manual to determine whether it requires updating or improvement, in particular, to reflect the current law and to take into account insights gained from the 2010/2011 floods.

Overland flow paths

Understanding overland flows is critical to achieving an appropriate design of a stormwater network.[185] This adds complexity to the planning regime, because it requires detailed mapping of overland flows in order to allow their assessment in relation to any new development.[186] The modern approach to planning is to accommodate overland flows as far as possible. This has not always been the case; some older houses are built in the middle of overland flow paths.[187] Current practice requires the road network to follow overland flow paths; historical practices resulted in some roads traversing overland flow paths.[188]

There is significant benefit to be gained by mapping overland flow paths, especially in urban areas where human intervention has altered the natural paths.[189] There is less likely to be a benefit to mapping flow paths outside urban areas.[190] However, only a limited number of urban councils map overland flow paths in their planning systems, probably because it is a difficult and highly detailed process.[191] Brisbane City Council has prepared detailed maps of overland flow paths. These ‘flood flag maps’ are made publicly available and used in the assessment of development applications, although the mapping is not yet complete.[192] Bundaberg Regional Council maintains local flooding models to help it manage stormwater flows in Bundaberg[193] and the surrounding areas and to assist in assessing development applications.[194] It has had difficulty attracting and retaining engineers with appropriate modelling experience,[195] but plans to build new models for other areas and upgrade its existing models.[196] Ipswich City Council is undertaking a number of drainage and flood studies intended to assist with future stormwater and runoff design, which include sub-catchment studies of overland flow paths.[197] Fraser Coast Regional Council has, since amalgamation, provided information on overland flow paths in flood searches and responses to requests for building information, although its knowledge of flow paths is based on observations from council employees and members of the public rather than on a hydraulic model.[198] Moreton Bay Regional Council has commissioned a study to prepare a flood database that will include information on overland flow.[199]

Given the benefits to be gained from properly mapped overland flow paths, such mapping is to be encouraged. The Commission's understanding is that these maps can be prepared most accurately using hydraulic models. The models used should be capable of being amended to reflect changed conditions on the ground, particularly in areas that are rapidly developing.[200] If site-specific or local overland flow models are developed, those models must be consistent with the overall hydraulic model of the catchment.[201] (Hydraulic models are discussed further in chapter *2 Floodplain management*.) The Commission recognises that the task is likely to be costly and resource intensive, and may be beyond the financial capacity of some councils.

Recommendation

10.9 All councils should, resources allowing, map the overland flow paths of their urban areas.

Detention basins

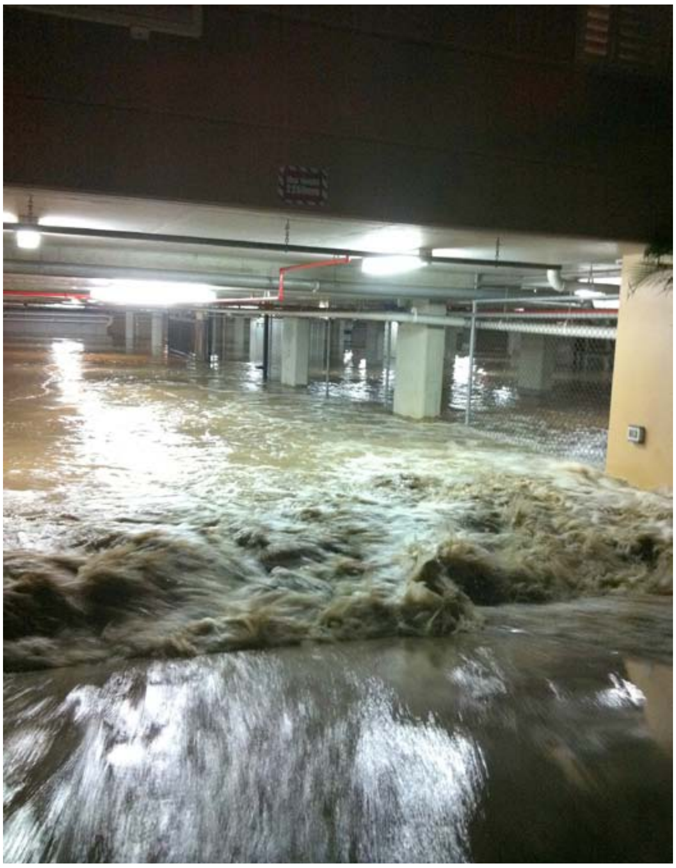
Detention basins are an important part of the stormwater network, particularly because, unlike other parts of the system, they are designed to manage large, sudden inundations.[202] Although they are sometimes used in cities (Bundaberg has seven major detention basins throughout the city as well as minor ones in car park areas),[203] the size of detention basins makes them more likely to be used outside central business district areas.[204] The amount of land they require means that their full cost includes not only their initial construction cost and continuing maintenance costs, but also the opportunity cost of the land's not being used for other purposes.[205]

10.2.4 Basements

Stormwater entered the basements of a number of high rise buildings in the 2010/2011 floods and caused damage. In some cases this was because basements were not adequately sealed, in others because the stormwater management systems installed in them were inadequate for the volume of water that entered. For example, one high-rise in the Brisbane central business district has stormwater pits in place to capture excess stormwater entering the underground levels of the building; these pits were unable to cope with the volume of water they received.[206] Similar problems occurred in a number of other apartment buildings. In one instance, a stormwater drain leaked and contributed to the inundation of the basement;[207] in another, the sump pumps designed to remove water from the basement failed because the electrical control board was inundated;[208] in a third, stormwater is believed to have entered a basement through leaking pipes.[209] Stormwater entered basements through a number of other channels including electricity and communication conduits[210] and air vents.[211] (The ingress of water through electrical conduits is discussed in section *10.3.5 Conduits for electrical cables*.)

The damage caused in basements was significant in those instances where essential services infrastructure, such as lighting, exhaust, security and air-conditioning systems and lift systems, was located in the basement.[212]

The Queensland Government Planner observed that there were currently very few requirements (legislative or otherwise) for ensuring that essential services in a building - including fire safety systems, electricity supply, water and sewerage - were not affected during a flood event. Building designers would, consequently, only consider the effects of floodwaters on services where it was a specific element of the design brief or where it was required by other non-building regulations.[213]



Floodwaters inundate car park of Regatta Apartments (photo courtesy Paul Rees)

If councils approve development applications that entail the location of essential services in basements, they should ensure either that the basement will be constructed with an appropriate level of flood immunity or that measures will be put in place to ensure those essential services continue to function even if the basement is inundated.

Basements do not necessarily have to be built to exclude stormwater: as noted above, some include stormwater pits or drains to manage stormwater rather than to exclude it. Whether this is appropriate will depend on the purpose and design of each individual building. However, plainly it is important that stormwater systems be constructed so that they do not exacerbate flooding. Some steps have already been taken by councils. For example, Temporary Local Planning Instrument 01/11, introduced by the Brisbane City Council in May 2011, requires that basements be built with a higher level of flood immunity than was previously required.[214] A Brisbane City Council town planner told the Commission that, following the 2010/2011 floods, the council has imposed conditions on the development approvals of basements in areas subject to inundation, requiring that stormwater connections be fully sealed to ensure that there is no possibility of backflow into basements.[215]

The Commission is aware of a proposal to amend the Queensland Development Code to impose a requirement that, in buildings in 'flood hazard areas', utilities (for example lift motors, switchboards and fire indicator panels) be designed or located to reduce the effects of floodwater on them during a defined flood event.[216] The Commission has not received detailed evidence on this proposal, but it seems that such a measure would provide an additional layer of flood resilience to essential services contained in basements.

The Commission received a submission that there should be an examination of the effectiveness of non-return valves in basements.[217] That kind of examination is more appropriately undertaken by Building Codes Queensland, which is presently considering whether non-return valves should be fitted on stormwater connections to private properties in designated 'flood hazard areas'. This remains a work in progress; there is uncertainty as to whether such valves are helpful in all circumstances.[218] (See section *9.5 Proposed new part of the Queensland Development Code: 'Construction of buildings in flood hazard areas'* for further discussion of the work being done by Building Codes Queensland.)

Recommendations

10.10 Councils should consider amending their planning schemes to include provisions directed to consideration of the flood resilience of basements as a factor in determining the appropriateness of a material change of use.

10.11 In assessing and determining development applications for material change of use in areas susceptible to flood, councils should consider whether the new developments locate essential services infrastructure above basement level, or, alternatively, whether essential services infrastructure located at basement level can be constructed so that it can continue to function during a flood.

10.2.5 The maintenance and optimisation of stormwater systems

The first stormwater infrastructure in Brisbane was constructed in 1860. It was to serve the needs of a population of around 5000.[219] It is, therefore, unsurprising that some of the oldest parts of the city are prone to flooding:[220] an increase in population density puts additional strain on the stormwater system, as every new hard surface, such as a road or driveway, increases the volume of runoff.[221] Many councils manage large networks of stormwater infrastructure: Fraser Coast Regional Council has approximately 500 kilometres of stormwater pipes and culverts;[222] Brisbane City Council has 2640 kilometres of enclosed stormwater pipes.[223] In all stormwater systems, continuing maintenance is critical to ensuring that the stormwater system operates to the full extent of its capacity. A program of upgrades is essential to ensure that the system has the capacity to serve the current population and level of development.

All parts of the stormwater network require a level of maintenance: for example, culverts need to be inspected for debris,[224] detention basins need to be mowed[225] and vegetation needs to be managed in natural waterways.[226] The inspection and maintenance of the pipe network is difficult because most of it is located underground. New technology, such as remote-controlled vehicles with cameras, has reduced the need for manual inspection by torch and mirror, but it remains a slow process.[227] With modern technologies, Brisbane City Council is presently able to inspect approximately 80 kilometres of stormwater pipes every year, which means that on average the entire system will be inspected once every 30 to 40 years.[228] The Council's ability to undertake additional inspections is constrained by both the cost of the work and the limited number of appropriately trained personnel.[229]

In light of these resource constraints, Brisbane City Council targets its inspection program at those parts of the pipe network most likely to require maintenance. Priority is determined on the basis of complaints from the public, observations in the field by council staff[230] and an active system of identifying the parts of the network likely to require maintenance in light of, for example, the age of those pipes and recent flooding.[231] Once a problem is identified it may be addressed immediately or noted as future work that will be prioritised according to the impact of the fault.[232] The 2010/2011 floods mean that higher priority will now be given to the pipes in flood-affected areas, since these are likely to have been silted up.[233] This will be a drawn out process, as over 450 kilometres of pipes were affected.[234]

Brisbane City Council has developed a similar system for prioritising upgrades to the stormwater network to the areas most likely to be in need. In Brisbane, some parts of the system were built to lower design standards than those now used and to serve a much lower population density than now exists, meaning that flooding inevitably occurs in those areas more frequently than would occur under modern design standards.[235] The cost of the work required to bring all parts of the system up to modern standards is high, hence the need for Brisbane City Council to prioritise the work by reference to various criteria.[236]

The Commission is aware of a specific issue in Emerald relating to the inundation of houses and businesses in the 2010/2011 floods, said to have been caused by flooding from a local irrigation drainage system, the LN1 system.[237] SunWater owns and operates the system, which runs from the western edge of Emerald to the Nogoa River. It was designed for irrigation runoff, but it now takes a considerable volume of urban stormwater flow; the rapid development of Emerald in recent years has led to an increase in runoff into it.The Central Highlands Regional Council commissioned a firm of environmental consultants to prepare a flood report on the streams and rivers directly impacting on Emerald. The final report, published in December 2011, made recommendations for structural work to be undertaken on the LN1 drain to increase its capacity and reduce pooling.[238]

The Commission is not in a position to make a technical assessment of the adequacy of the LN1 system, but notes that a significant obstacle to such an assessment's being made, including as to any appropriate remedial steps to be taken, is the lack of a formal agreement between SunWater and the Central Highlands Regional Council about who should take ownership of the LN1 system and who should take responsibility for maintenance of the LN1 system.[239] This needs to be resolved expeditiously.

The Commission has also been made aware of problems with a stormwater drain in Moore Park, a beachside suburb of Bundaberg. The drain, which runs through the middle of the residential area of Moore Park, is one of the two main drains which serve the Moore Park community. Residents raised concerns with the Commission about the maintenance of the drain and the drain's effect on the area's susceptibility to flood.[240]

As with the LN1 drain in Emerald, the Commission is not in a position to assess the adequacy of the Moore Park town drain. However, given the drain's significance to the Moore Park area and the concerns expressed by residents, the Commission considers that the Bundaberg Regional Council should investigate the adequacy of the drain to serve the area.

Recommendations

10.12 SunWater and the Central Highlands Regional Council should determine the issues of ownership and responsibility for maintenance of the LN1 drain system in Emerald.

10.13 The Bundaberg Regional Council should investigate the adequacy of the drain and take reasonable steps to ensure the Moore Park area is effectively served.

10.2.6 Backflow flooding

Backflow flooding of the stormwater network can occur where a stormwater pipe runs from a low-lying area to a discharge point located near a waterway. If the discharge point becomes submerged by a tide, storm surge or floodwater, water can pass back through the pipe and out of inlets and manholes.[241] If the banks of the waterway are higher than the low-lying area, flooding may occur in the low-lying area even though the banks are unbroken.

Backflow flooding occurred in a number of locations in the 2010/2011 floods, but was reported particularly in low-lying areas of Brisbane such as the central business district, Rosalie, Milton, New Farm and Auchenflower.[242] Residential properties were flooded and the basements of a number of large buildings were inundated by backflow flooding,[243] although typically the river's breaking its banks caused higher flood levels.[244]

In low lying areas, water rising out of the drains has been a problem for many years.[245] Some low lying streets in the Auchenflower area often have water over them in king tides.[246] In January 2011, Rosalie residents and business owners witnessed floodwaters flowing from drains at Nash Street,[247] at Torwood Street[248] and in other areas of Rosalie and Auchenflower.[249] The Commission heard evidence that in the Brisbane city centre there was backflow of water through the drains in Albert Street.[250] As discussed above, high-rise residential units were inundated by stormwater and backflow into their basements, as well as by water from the Brisbane River's breaking its banks.[251]

Before the 2010/2011 floods, many residents of Brisbane associated flooding solely with the overtopping of rivers.[252] As backflow flooding occurs when river levels are elevated, but below the point at which the banks are overtopped, the risk of the river overtopping is not necessarily a useful measure of the likelihood of flooding.[253] People living in areas susceptible to backflow flooding should be made aware of the risk, to ensure that they can make proper preparations before and during a flood.[254] Making such information readily available to the public would also assist prospective purchasers of a property in such areas to make better informed decisions. The preparation of flood maps and the dissemination of the information they present to the public is considered in chapter *2 Floodplain management*.

The problem of backflow flooding will become more frequent and more severe if present predictions about climate change become reality.[255] Higher tides will mean that more drainage outlets become submerged during high tides and flooding.[256] This is an important consideration for councils seeking to enhance their flood resilience. It is not an issue that can be addressed simply by building higher banks or levees; these structures prevent surface inundation but do not prevent backflow through underground pipes.[257]

The risk posed by backflow flooding can be managed through planning and design standards. Modern development standards require that properties have higher ground floors. This reduces the risk of damage from any backflow flooding.[258] Constructing stormwater outlets at higher levels can reduce the frequency of backflow flooding; however, there is a limit to the height at which they can be positioned, because stormwater systems require a minimum gradient to make use of gravity.[259]

An alternative remedy for backflow flooding is the installation of backflow prevention devices. These are one-way or non-return valves that are designed to allow stormwater to discharge from a pipe into a waterway, but to close and seal against rising water in the waterway. Backflow flooding, at least in Brisbane, is a problem mainly in areas where the stormwater drainage systems were built prior to the implementation of modern planning codes (which place greater emphasis on drainage issues than older codes).[260] Backflow prevention devices can be retrofitted to stormwater outlets in these systems. They are presently used in New Farm, Yeronga, West End and Newstead in Brisbane[261] and it is likely that if they had been fitted more widely some of the flooding of low-lying areas of Brisbane during the 2010/2011 floods would have been avoided, at least up until the point when the river overtopped its banks.[262] They are also used in other locations; for example, the Maryborough central business district has a shut off-valve to prevent overloading of the stormwater system during flood, as well as a number of valves used to manage tidal inundations.[263]

The Commission received detailed evidence on the use of backflow prevention devices from an environmental consultant presently conducting a review for the Brisbane City Council[264] and from an engineering consultant appointed by the Commission to provide an independent assessment of the usefulness of the devices.[265]

There are a number of types of backflow prevention devices, each of which have certain advantages and disadvantages and may be more or less suitable in different environments. They include:

- Flap gates, which are hinged flaps or gates fitted at the stormwater discharge point. They normally fall closed under their own weight, but open when the pressure from the build up of stormwater inside the pipes is sufficient to open the gate. They will close when the pressure outside the pipes, such as hydrostatic pressure from a rising waterway, is greater than that inside the pipe.[266] They operate by a simple mechanism and are relatively inexpensive compared to other backflow prevention devices. They require regular maintenance to ensure that they are not prevented from closing by silt, debris or marine organisms such as barnacles.[267]
- Duckbill valves, also called duckbill check valves, which are made of a flexible moulded material and normally have a closed vertical face. That face transforms into a more open face to allow discharges when the pressure builds inside the pipes and will close when there is greater pressure outside.[268] They are usually more expensive to install than flap gates and also require maintenance to ensure they are not blocked by silt or debris. They can be purchased pre-treated to prevent marine organisms' causing their failure.[269] Generally, less structural work is required to retrofit a duckbill valve onto an existing pipe than to fit a flap gate.[270]
- Mechanically operated valves, which exist in various forms.[271] They are either operated manually or by electronic sensors. They are significantly more expensive both initially and in terms of maintenance costs than flap gates or duckbill valves, particularly if they operate using sensors. Typically they are used only on industrial installations or at sewerage treatment plants where there are staff permanently onsite.[272]

The selection of the type of valve for use in a particular location will depend on a number of factors: construction costs, continuing maintenance and operation costs, the level of monitoring and maintenance required and the environment in which it will need to operate.[273] Backflow prevention devices are not appropriate for all stormwater pipes. While they operate to prevent backflow from occurring, the devices may impede the flow of water through the stormwater network, and in some circumstances may exacerbate local flooding because of the head loss they cause to the system.[274] In some locations the cost of installing the device may be disproportionate to the expected benefits and there may be better alternative flood mitigation steps. For example, Brisbane City Council's environmental consultant commented that in some areas, such as Auchenflower, it would be more cost-effective to augment the river bank (affording greater protection against riverine flooding) than to install a backflow prevention device.[275] In certain circumstances, backflow prevention devices may, by causing greater flows of water over banks which are overtopped, increase erosive damage to those banks.[276]

It is, accordingly, important to ensure that prior to any installation of a backflow prevention device, a full risk assessment is undertaken, which will likely include a full survey of the site and the affected stormwater network.[277] The use of backflow prevention devices is presently being considered by the Brisbane City Council; a recommendation for a full survey and risk assessment was made by the Flood Response Review Board of the Brisbane City Council.[278] Each of the expert consultants retained by, respectively, the Brisbane City Council and the Commission, was of the view of that backflow flooding risk assessment should be undertaken by all near-coastal councils.[279] Although the risk of backflow flooding caused entirely or in part by tides is limited to near-coastal councils, other causes of flood, such as rain, can also result in backflow. It would therefore be prudent for all councils to periodically conduct risk assessments to identify areas at risk of backflow flooding.[280]

Recommendations

10.14 All councils should periodically conduct risk assessments to identify areas at risk of backflow flooding. In respect of such areas, councils should consider how such risks can be lessened, including in that process consideration of the installation of backflow prevention devices. Backflow devices should not, however, be installed unless and until a full risk based assessment has been undertaken.

10.15 Councils should conduct education campaigns directed to ensuring that all residents and property owners in areas identified as being at risk of backflow flooding are aware of the circumstances in which backflow flooding can occur, the hazard it presents and what should be done if it occurs.

10.3 Electrical infrastructure

10.3.1 The electricity supply industry in Queensland

The 2010/2011 floods caused widespread damage to the electricity network in Queensland. In many locations power outages occurred even where the local electrical infrastructure was not damaged, either because of damage elsewhere to connecting parts of the network, or because the electricity was disconnected as a precaution. While frustrating for some customers who lost power although they were not directly affected by flood, such precautionary disconnections are vital. Water conducts electricity; if floodwater comes into contact with a live source of electricity there is both a risk that someone in contact with the water may suffer an electric shock and a risk that the electrical infrastructure may short circuit and be damaged, possibly failing explosively.[281] (Precautionary disconnections were considered in the Commission's interim report in the context of flood preparedness and emergency response, see section *6.1.1 Power* of the interim report.[282])

Queensland's electrical supply industry is divided into generation, transmission and distribution functions. Generators such as Tarong Energy, Stanwell and CS Energy produce electricity. The generators are connected to the transmission network, which is operated by Powerlink Queensland. The transmission network connects to the distribution network, which provides the link to the consumer of the electricity and is operated by electricity distributors. In Queensland there are two major distributors: Energex and Ergon Energy. Both are government owned corporations under the *Government Owned Corporations Act 1993*. Each is responsible for a different geographic area.

Energex is responsible for the electricity distribution network throughout south-east Queensland, including the regions of Brisbane, Ipswich, Gympie and the Lockyer Valley that were affected by the 2010/2011 floods.[283] Energex supplies electricity to more than 2.8 million people.[284]

Ergon Energy distributes electricity to regional Queensland.[285] It serves about 1.4 million people across a network area of 1.7 million square kilometres; about 97 per cent of Queensland.[286] Its network is vast: it includes approximately 150 000 kilometres of overhead powerlines, 6200 kilometres of underground power cable, 1 million power poles, 370 zone substations, 530 major power transformers and 90 500 distribution transformers.[287]

The assets that comprise the distribution networks can be divided into two different categories, known as 'customer dedicated assets' and 'shared network infrastructure'. Each of these categories is discussed separately in this chapter.

Customer dedicated assets are constructed inside customer premises and are usually commercial and industrial substations. Despite the use of the term 'customer dedicated', these substations may also used to supply shared areas outside of the building they are housed in.[288]

All other distribution network assets are 'shared network infrastructure'. Shared network infrastructure consists of the assets used to distribute electricity throughout Queensland, other than customer dedicated assets.[289] It includes major bulk and zone substations, both of which supply electricity to many thousands of customers.[290] It also includes overhead lines, underground cables and pole mounted and ground mounted distribution equipment.[291]

10.3.2 The impact of the 2010/2011 floods on distribution infrastructure

Energex infrastructure (south-east Queensland)

On the afternoon of 11 January 2011, Energex was warned that flood levels in the Brisbane and Ipswich areas were likely to be similar to those experienced in 1974.[292] It began taking steps to disconnect supply to substations and feeder systems and remove equipment from the substations it considered likely to be affected by flood. These included 10 major commercial and industrial substations in the Brisbane central business district and approximately 120 feeder systems throughout Brisbane and Ipswich.[293]

In the Brisbane central business district the substations that were pre-emptively disconnected were generally located below ground level.[294] A number of transformers throughout the central business district were also shut down because of the risk of water ingress during the anticipated flooding.[295] The effect of this was that buildings which did not flood, but whose electricity was connected to other buildings that did flood or were seen as at risk of flooding, were without power. Energex also disconnected electricity to private properties in the suburbs of Ipswich and Brisbane that were likely to be flooded, or were connected to assets likely to be flooded.[296] As a result, many properties in those suburbs that did not flood (and may have been at no risk of flooding) still experienced a loss of power.

Energex did not have the time or resources to pre-emptively disconnect every location. For example, the substation in the Brisbane suburb of Milton was not disconnected. When floodwater entered the terminals in the substation it caused an explosive electrical fault.[297] This substation is discussed in more detail in section *10.3.3 Shared network infrastructure* below.

Even where pre-emptive measures were taken, some infrastructure was still damaged. Damage occurred at all levels of the supply system, causing interruptions to assets further down the distribution network. For example, the broader Moggill region in Brisbane is provided with electricity via five high voltage feeders. Each of those feeders was affected by flood in some way (for example by fallen trees or fallen powerlines). This created an area within which no electricity was available for a time.[298]

In total, the 2010/2011 floods caused 300 000 customers in Ipswich and Brisbane to lose power.[299] Twelve thousand homes and businesses in south-east Queensland were flooded.[300] Ninety per cent of the high voltage feeders were operating again by 15 January 2011.[301] The restoration of power took some time; Energex required flood-affected properties to be inspected before it would reconnect the electricity.[302] Where Energex considered that electrical safety had been compromised, the customer was issued with a disconnection notice that could not be revoked until a qualified electrician had inspected the premises.[303]

The sudden and unexpected nature of the flash flooding in the Lockyer Valley meant that Energex was not able to pre-emptively disconnect supply to its electricity assets in that region.[304] Many of those assets were flooded, which tripped automatic switches that disabled the assets. While the switches operated as they were designed to, the repair process was more difficult and took longer than would have been the case if the assets had been pre-emptively disconnected.[305]

Much of the electricity infrastructure in the Lockyer Valley region was destroyed.[306] The most serious damage was experienced in and around Murphys Creek, Helidon, Grantham, Withcott, Lake Clarendon, Spring Creek and Carpendale.[307] The water washed away lines that were near watercourses, and ground mounted switch gear and transformers were inundated.[308] The water surge on Monday 10 January 2011 affected the main feeder lines to the region, causing 5000 customers to lose power.[309] Some 80 Energex crews worked extended hours for two weeks restoring power to homes and businesses in the Lockyer Valley;[310] thirty-one poles and 18 transformers had to be replaced and over 36 kilometres of line had to be reinstalled.[311]

About 25 zone substations (which provide the power to the distribution network) throughout south-east Queensland lost supply during the floods.[312] At the peak of the electrical interruptions, approximately 150 000 people were left without supply.[313] That interruption, however, was principally caused by the loss of the incoming power supply rather than flooding to the zone substations.[314] Only eight zone substations lost supply directly because of flood damage.[315]

Approximately 475 of Energex's distribution substations were affected by floodwater; of those 120 had to have major components replaced.[316] Some supplied only one building, but others were the connection points for a number of feeder routes and caused power outages to several buildings.[317]

Apart from the damage to substations, many other pieces of infrastructure were affected. Among other things, 101 distribution transformers, 55 switch fuse gear items, 55 substation relays, 3645 watt hour meters, 95 power poles and 98 kilometres of overhead cable had to be replaced. [318]

Ergon Energy infrastructure (outside south-east Queensland)

The 2010/2011 floods affected approximately 600 000 square kilometres (or 35 per cent) of Ergon Energy's total distribution area.[319] The floodwaters remained in some areas for as long as two weeks and some towns experienced a number of floods in December 2010 and January 2011.[320]

However, Ergon Energy reported that the damage to its infrastructure was, in overall terms, relatively minor.[321] The total cost was estimated to be in the order of $6 million.[322] By way of comparison, the damage Cyclone Yasi caused to Ergon's infrastructure was in the order of $60 to $80 million; and during the cyclone, about 220 000 customers lost electricity supply, compared with approximately 8300 during the 2010/2011 floods.[323] Ergon's primary assets are poles and wires, which are less susceptible to flood inundation than to damage caused by severe storms and cyclones.[324]

The outages that occurred throughout the Ergon Energy network were primarily caused by electricity being disconnected pre-emptively in response to the threat to public safety that would have been caused by floodwaters coming into contact with sources of live electricity.[325] Ergon Energy staff monitored forecast flood levels and determined which assets would be disconnected.[326]

10.3.3 Shared network infrastructure

Planning considerations

Damage to shared network infrastructure can disrupt the supply of electricity to large numbers of people, including those in premises not flooded if the shared network infrastructure supplying them runs through areas that have been damaged by flooding.[327]

The *Sustainable Planning Regulation 2009* divides shared network infrastructure into two categories:

- the construction of a new zone substation or bulk supply substation or the augmentation of an existing zone or bulk supply substation if the input or output standard voltage is significantly increased
- all other aspects of the supply network.[328]

The regulation's effect is that only work in the first category can be declared assessable development,[329] which in turn means that all other aspects of the supply network are exempt development.[330] Exempt development does not require a development approval, nor is it required to comply with planning instruments other than state planning regulatory provisions.[331]

The result, generally, is that when new substations are developed or significantly augmented, the local council planning schemes will apply, but for all other electrical infrastructure development they will not. In addition, the Brisbane City Council reported that it is 'not uncommon' for the community infrastructure designation process under the *Sustainable Planning Act 2009* to be used to designate land for operating works (which includes substations)[332] under the *Electricity Act 1994*, so that the development becomes exempt development and cannot be assessed under the Brisbane planning scheme.[333] However, the *Sustainable Planning Act* does allow requirements about works for community infrastructure (including requirements about its height and location) to be imposed as part of its designation as land for community infrastructure, even though it is exempt development.[334]

Energex explained that its zone substations or bulk supply substations are built on blocks of land that it owns; it endeavours to ensure those areas are as 'flood-proof as possible'[335] and purchases sites above the applicable defined flood level.[336] If a major bulk or zone substation is required in an area susceptible to flood, Energex will usually construct the new assets within the substation above the defined flood level.[337] Similarly, new work on existing assets in areas susceptible to flood is, where possible, carried out above the defined flood level.[338]

State Planning Policy 1/03 applies to the planning of bulk subsupply stations and zone substations. The State Planning Policy 1/03 Guideline provides that substations should be able to function effectively during, and immediately after, floods, and that they should not be built below the level of a flood with a 0.5 per cent annual exceedance probability.[339] The location of other network infrastructure is the responsibility of the distributor.

The *Electricity Act* requires distributors to provide electricity to any person who applies for connection.[340] That means that where there are residents or businesses in areas susceptible to flood, overhead lines, underground cables and other associated equipment forming part of the shared network infrastructure must be constructed and may be located below the defined flood level.[341] Such infrastructure follows the terrain; consequently, it is not always possible to provide flood proof infrastructure in every area.

The Commission examined two substations, both built in the last 10 years and both affected by flooding during the 2010/2011 floods, as case studies to consider their performance in the floods and to identify whether changes to the planning of substations and shared network infrastructure may be required.

Milton substation

Energex's Milton substation is housed in the southern plaza of Suncorp Stadium. This was not where Energex had initially intended to build the substation.

Energex had identified the future need for a substation in Milton prior to the development of the stadium and had purchased various parcels of land for this purpose between 1990 and 1995.[342] It had expected to build the substation in or about 2004.[343] The load demand created by the stadium redevelopment, which was required to be completed by March 2003, and an increase in local demand, meant that the substation needed to be constructed earlier than Energex had intended.[344]

In September 2000, the Queensland Government designated the land on which the stadium is built as land for community infrastructure.[345] The stadium development itself was declared to be a significant project requiring an environmental impact statement under the *State Development and Public Works Organisation Act 1971* and an assessment statement was prepared dated August 2000. (Development declared to be a significant project has been considered by the Commission in chapter *6 Satellite planning legislation*.) The environmental impact statement did not make any reference to flooding (an issue considered further in chapter 6) although it did, relevantly, indicate that the southern plaza of the stadium was a possible site for Energex's substation.[346]

At around the same time, in September 2000, the Queensland Government asked Energex whether it would sell the land it had purchased for the substation for use as part of the stadium development. Energex was reluctant to do so because it considered the site critical for energy supply and had already undertaken cabling and tunnelling works in preparation for its development.[347] However, in November 2000 the Queensland Government issued to Energex a notice of intention to resume the land for the stadium redevelopment.[348]

Following receipt of the resumption notice Energex searched, without success, for an alternative site for the proposed substation. One difficulty was that 110 kilovolt cables running from Ashgrove West had already been installed for the substation. To move the cables from the planned route point by just 100 metres would have added $1.5 million to the cost of developing the substation.[349]

Meanwhile, the council approved the stadium development application in March 2001, and a negotiated decision notice was issued in May 2001. Condition 10 of the notice required all new proposed buildings to have finished floor levels above the Q100 level.[350] Two months later, the Minister for State Development exercised his 'call-in' powers pursuant to the *Integrated Planning Act 1997* and re-decided the development application. The decision notice he issued did not contain an equivalent to the council's condition 10.[351]

Unable to find a suitable alternative site, Energex had discussions with the Queensland Government about the location of the substation.[352] Energex's preference was to place the substation in the northern plaza of the stadium, which was a higher site and accordingly had a better flood profile.[353] The stadium architects examined the proposal but concluded that it would be impossible to disguise the mass of the building and that its operating noise would also create a difficulty.[354]

Energex disagreed with this assessment, but acknowledged that the substation could be developed in the southern plaza.[355] Energex wrote to the Queensland Government and said that: [356]

- the southern plaza site was acceptable, although extremely crowded, from the point of accommodating all substation equipment
- the site was well below the Brisbane City Council's predicted Q100 flood level
- the Brisbane City Council had advised Energex that given the value of the infrastructure being considered, a 'greater flood immunity' than Q100 might be appropriate

- given the disadvantages of the southern plaza, including flood susceptibility and difficult cable access, Energex preferred the northern plaza.

Ultimately the Queensland Government's preference prevailed and the southern plaza was selected to house the substation.

While the southern plaza was partly above the 1% AEP level, because of site constraints the cable basement had to be built below the 1% AEP level.[357] An overhead walkway to the Milton Railway Station meant that the height of the substation could be no more than 10 metres above the 1% AEP level.[358] Consequently, the floor level of critical equipment was placed at the 1% AEP level without any freeboard.[359] Energex viewed this flood risk as manageable because that part of the substation, if submerged, would not subject live high voltage electrical components to floodwater.[360]

Floodwaters surround the southern end of Suncorp Stadium, January 2011 (photo: Matthew Palmer)

The January 2011 flood reached 0.95 metres above what was the Brisbane City Council 1% AEP level for the Milton substation at the time of its construction.[361] Some design features meant that the entire substation did not go offline in the flood. For safety reasons, individual feeders and other components were switched offline to interrupt supply to flood-affected areas.[362] However, there was significant damage to the substation, mainly from water and debris ingress, to the equipment and floors below the flood level.[363] Some damage was caused by the collapse of ducting and structures under the weight of mud and debris.[364]

Energex estimates that the cost of rectifying the damage to the substation was $750 000.[365] It plans to implement new flood resilience measures, including building bunds around the switchroom, installing sump pumps on the switch room floor, sealing vents below the defined flood level and replacing all local power sockets below the defined flood level with appropriately rated outlets.[366]

Bundaberg Central substation

The Bundaberg Central zone substation located on Walla Street, Bundaberg South is owned by Ergon Energy.[367]

Ergon Energy had investigated other sites in the area prior to building the substation on Walla Street, but was unable to find any alternative flood free sites suitably sized and located.[368] Bundaberg City Council approved Ergon's development application for the establishment of the electrical substation on the site in 2007. The development approval required essential services infrastructure to be built above the defined flood level of 8.5 metres.[369]

Consistent with that condition, the works specification for the substation prepared by Ergon Energy required all critical outdoor equipment to be located above 8.8 metres and all indoor equipment to be located above 9.55 metres.[370]

On 28 December 2010, floodwaters began to enter the substation's yard. As a precautionary measure Ergon Energy disconnected the yard equipment due to the uncertainty of the forecast flood levels.[371] Although there was a large amount of water in the yard around the substation, water did not reach the building or essential infrastructure on the site.[372]

The distributors' proposed new resilience measures

Following the 2010/2011 floods Ergon Energy and Energex have both reviewed their flood resilience measures for infrastructure located in areas susceptible to flood.

Ergon Energy recently revised its flood level standard for the establishment of new bulk supply and zone substations. Its new standard requires zone substations to be built at or above the 0.5% AEP flood level. If infrastructure is to be located below that level, resilience measures must be taken so that the substation can operate effectively during and immediately after a flood up to the height of the recommended flood level.[373] Where a substation is proposed, but the 0.5% AEP flood level is not presently known, and it is believed that flood risk exists in relation to the proposed site, Ergon Energy will obtain a hydrological assessment by an external consultant.[374]

Ergon Energy suggested that greater flood resilience would be achieved if more overhead assets were developed, as opposed to underground or on the ground structures. It noted, however, that in its experience, local authorities normally require underground or on ground infrastructure in new urban developments.[375]

Energex is considering implementing additional resilience measures for its substations, particularly the four that were directly affected by flood in January 2011. They include moving critical equipment to higher locations, installing bunds around substations and installing automatically activated sump pumps.[376]

These resilience measures are directed to ensuring that critical infrastructure is built so that it can continue to operate during and immediately after major floods (as was the case for the Bundaberg Central substation).

During the Commission's public hearings Energex was asked about its capacity to isolate parts of its network, so that only directly affected areas lose electricity, rather than disconnecting whole service areas.[377] Energex explained that isolating discrete parts of the network is not simple. Many high voltage feeders are built across areas that flooded in the 2010/2011 floods. These feeders supply electricity to a large number of customers. When one goes offline it is virtually impossible to avoid disconnecting people further down the line. Energex is considering installing connection points in the network for generators to supply electricity to customers who were not experiencing flooding, but had lost power supply because flooding had cut supply at another location.[378] This appears to be a logical means of dealing with the problem.

Amendments to planning requirements for electrical infrastructure

Flood resilient electrical infrastructure is important, not least because other essential services needed during and after a flood depend on electricity to operate.

The Milton substation case highlights the importance of ensuring that flood resilience is given priority in the location and design of essential electrical infrastructure. The initial concerns of Energex about the site were borne out: important infrastructure was damaged; this was not only inconvenient but also created a safety hazard. There were significant costs associated with restoring the substation, and the additional flood resilience measures now being implemented will be expensive. The decision to place the site in the south plaza, which was more susceptible to flood, was driven by considerations other than flood; the Commission is not in a position to say that the decision was wrong. However, the example demonstrates the importance of giving proper weight to flood risk when considering where to locate substations.

The example of the Bundaberg Central substation illustrates how to ensure essential infrastructure continues to operate during severe floods. Achieving flood resilience was an objective from the outset and was an important consideration in the selection of the site. The scope of works prescribed detailed minimum specifications and its requirements reflected the attention given to flood risk and resilience. The end result was that following an inspection, some testing and cleaning, the substation was returned to full capacity in the evening of 1 January 2011, just three days after the flood peak.[379]

The flood resilience measures proposed by Energex and Ergon Energy for infrastructure located in areas susceptible to flood are important for at least two reasons. First, there is a need to protect existing infrastructure that cannot practically be moved to a site with greater flood immunity (for example, the Milton substation). Second, the statutory obligation to provide electricity means that new development of electrical infrastructure in areas susceptible to flooding may be unavoidable. Such initiatives by the distributors are welcome; it would also be beneficial for the Queensland Government and councils to impose minimum standards for electrical infrastructure in the planning regime.

Flooding at Ergon Energy's Bundaberg Central Substation (photo courtesy Ergon Energy)

It is the Commission's view that critical infrastructure in assessable substation developments should be built with the objective that they remain operational during and immediately after a flood. In some cases, it would be prohibitively expensive to build infrastructure to withstand the probable maximum flood. The magnitude of the flood that the infrastructure should be able to withstand is dependent on what is acceptable to community and government; a risk assessment should be conducted to determine that level. This risk assessment should be done as part of the tailoring of model flood planning controls to take account of local circumstances. Whatever the magnitude of the flood chosen, steps should be taken to make the infrastructure resilient to it. In some cases, this may be best, and most practically, achieved by placing the critical infrastructure at a height where it is not susceptible to flood waters. In others, the objective may be best achieved by adopting other flood resilience measures.

Recommendations

10.16 The Queensland Government should draft assessment criteria to be included in the model flood planning controls that require critical infrastructure in assessable substation developments is built to remain operational during and immediately after a flood of a particular magnitude. That magnitude should be determined by an appropriate risk assessment.

10.17 If the Queensland Government does not include such assessment criteria in the model flood planning controls, councils should include assessment criteria in their planning schemes that require critical infrastructure in assessable substation developments is built to remain operational during and immediately after a flood of a particular magnitude. That magnitude should be determined by an appropriate risk assessment.

10.18 The Queensland Government should consider measures to ensure that requirements are included in the designation of land for community infrastructure under the *Sustainable Planning Act 2009* to ensure that critical infrastructure for operating works under the *Electricity Act* is built to remain operational during and immediately after a flood of a particular magnitude. That magnitude should be determined by an appropriate risk assessment.

10.19 Electricity distributors should consider installing connection points for generators to provide electricity supply to non-flooded areas that have had their supply cut during floods.

10.3.4 Customer dedicated assets

Customer dedicated assets are commercial and industrial substations located inside an electricity consumer's premises. The Commission received evidence that some substations housed within buildings in the Brisbane central business district flooded and stopped operating during the January 2011 floods and remained inoperative, often for lengthy periods of time, after the floods.

The Stamford Plaza Hotel, built in 1984, is a multi-storey hotel located on Edward Street in Brisbane. It is approximately 10 metres from the river.[380] The building has a two-storey basement. The first floor is a car park and the second floor of the basement, used for various purposes, has an Energex substation housed within it.[381]

At around midday on Tuesday 11 January 2011, the security manager of the hotel suspected that the basement was going to flood and made the decision to evacuate property in the basement to the third and fourth levels of the hotel.[382] At 6.20 pm that evening, water had not started to enter the basement, but was close to doing so; Energex advised at that time that power would be cut to its substation but could not say exactly when.[383] Power was cut at 10.10 pm. Two hundred guests were in the building.[384] As the lifts were not operational, they had to use the fire escape, lit with candles and torches, to evacuate.[385] A generator in the basement could not be used, because the basement could not be isolated from its circuit; if the generator had been switched on it would have made the basement, filled with water, live with electricity.[386]

The hotel was without power for seven weeks. It was not able to reopen until 31 March 2011, and then only on a limited basis because the basement was still being reconstructed.[387] The Energex substation was replaced in its original position: because of its size there was nowhere else to put it. The generator circuit has, however, been upgraded so that damaged parts of it can be isolated in any future flood.[388]

A contrasting case was Festival Towers, a 41-storey development at 108 Albert Street, Brisbane City. Development approval for the building was granted in 2002.[389] The building has a four-level basement car park, and the two lower basements flooded in January 2011.[390] The essential services at Festival Towers were above the defined flood level. The electrical switchboards and the substation were placed on level one of the building,[391] with the result that the building was able to remain almost fully operational throughout January 2011 floods.[392]

Planning considerations

The *Electricity Act 1994* and the *Electricity Regulation 2006* require that if a distributor reasonably considers it necessary to install a substation on the premises of a customer, the distributor may require the owner of the premises to provide, amongst other things, the space for a substation.[393] However, while the regulation requires the customer to provide space for a substation, it does not mandate where the space is to be located. In particular, it does not mandate that the space be above the defined flood level.

State Planning Policy 1/03 requires that 'essential services infrastructure (e.g. on-site electricity, gas, water supply, sewerage and telecommunications) maintains its function during a [defined flood event]'.[394] However, it only applies if a council has identified a defined flood event.

In response to the 2010/2011 floods, both Brisbane City Council and Ipswich City Council introduced temporary local planning instruments. The Brisbane City Council temporary planning instrument now requires essential infrastructure to be built above the defined flood level, and in the case of residential buildings, that it have a 500 millimetre freeboard. It defines essential infrastructure as including:[395]

> any room used for fire control panel, telephone PABX, sensitive substation equipment including transformers, low voltage switch gear, high voltage switch gear, battery chargers, protection control and communication equipment, low voltage cables, high voltage cables, and lift controls etc.

The Ipswich temporary planning instrument also introduced new requirements for the location of essential infrastructure. The temporary planning instrument suspends part of the Flooding and Urban Stormwater Flow Path Areas of the Ipswich planning scheme and relevantly replaces it with requirements that:[396]

- electrical installations are sited in the area of 'greatest flood immunity'
- electrical switchboards, main data servers and the like are positioned above the adopted flood regulation line with all electrical and data installations below this level designed and constructed to withstand submergence in floodwater.

The Queensland Reconstruction Authority has also produced a guideline: 'Planning for stronger, more resilient electrical infrastructure'. The guideline proposes that in new high rise building design electrical equipment should be raised and electrical infrastructure located above the defined flood level (as opposed to the traditional basement location) to improve resilience against flooding.[397]

Energex told the Commission that it was liaising with the Brisbane City Council to amend the development approval guidelines to incorporate requirements to improve the flood resilience of Energex substations within new developments.[398] Energex said that it presently encounters difficulties in having input into the location of substations in buildings as the developer has often determined the position of the electrical infrastructure before approaching Energex.[399] By the time Energex is approached developers have often already obtained development approval and the approvals ordinarily contain detailed designs and plans.[400] The decision has effectively been made before Energex is involved.

Flooding of customer dedicated assets was a cause of great inconvenience and disruption – it meant that people were unable to return to their places of residence or businesses for lengthy periods of time. For future development it presents as a problem with a simple solution: customer dedicated assets should not be built in basements.

The location of existing customer dedicated assets presents more difficulty. Given their size and weight, it may be difficult to move them. The impact of flooding may be mitigated through other measures such as bunds, pumps and through designing circuits that can be isolated to allow electricity to be provided from another source.

Energex submitted that amending the *Electricity Regulation* to require electricity customers to supply space above the defined flood level for substations would be one way to improve flood immunity.[401] Energex noted that a risk associated with amending the legislation was that there was no legal link to the *Sustainable Planning Act 2009* assessment process, creating the prospect that any amendment to the *Electricity Regulation* might be overlooked.[402] However, Energex also noted that some councils placed conditions on development approvals or provided advice on development applications that alerted developers to the need to liaise with Energex about connection requirements. Energex suggested, therefore, that amending the regulation would work best in conjunction with planning controls.[403] Energex appears to prefer a state planning regulatory provision as a planning control, requiring customer dedicated substations to be built above the defined flood level.[404]

Recommendation

10.20 The Queensland Government should consider whether there should be a legislative requirement that customer dedicated assets be built at or above the applicable defined flood level and if so, the Queensland Government should consider which legislation should contain such a requirement.

10.3.5 Conduits for electrical cables

Electrical infrastructure includes underground cables that supply power to larger buildings. These form part of the shared network infrastructure. To facilitate the supply of electricity to commercial and industrial premises, electricity distributors run electrical cables from the footpath through conduits into the substation enclosure inside the customer's building.[405] Accommodating the conduits is part of the customer's obligation under the *Electricity Regulation* to provide space for network infrastructure.[406]

The Commission received evidence that the fact that these conduits were not sealed against water allowed water to enter basements in some Brisbane central business district buildings during the 2010/2011 floods. Other forms of conduit – for example, those providing utilities such as telephone and data lines – may also have caused flooding in buildings.[407] Energex's executive general manager of network performance estimated that twenty buildings may have had their basements inundated by water entering through electrical conduits.[408]

Witnesses to flooding at the Festival Towers building reported that from 9.00 am on 12 January 2011 water was entering the basement of the complex through two 'waterfalls'. The sources of these 'waterfalls' were likely to be unsealed conduits.[409] The first was an Energex conduit that carried power to the building.[410] The second was a conduit that carried communication services into the building.[411] The Energex conduit appears to have been the main source of the water entering the basement; a witness observed that water had ceased to flow through the communications conduit by the afternoon of 13 January 2011.[412]

A Brisbane City Council representative explained that the council did not consider any flood risk caused by Energex conduits because such development was not assessable under the Brisbane City Council's planning scheme.[413] She observed that while the council might impose a condition on new basements, the reality was Energex might subsequently install further or altered services unaffected by such conditions. In her view, the method of installing, sealing and waterproofing utilities was a matter between the utility provider and the developer.[414]

Another property which may have flooded, in part, from unsealed energy conduits was the River Park Central Apartments. Located on Mary Street in Brisbane City and completed in 2004, the complex has 120 residential units over 30 levels. The building has a one-level basement; below the basement is an electrical substation which is connected to conduits that carry cables.[415] During the January 2011 flood, a resident saw water coming from near where the substation was located.[416] The precise source of this water was not identified, but the resident suspected it came from the electricity cable conduits.[417]

Energex acknowledged that it does not presently seal conduits to keep out large flows of water under pressure. Energex's commercial and industrial substations manual requires conduits to 'be securely sealed by the consumer in an approved Energex manner … to prevent ingress of dirt until cable installation by Energex'.[418] It does not address the ingress of water.[419] Energex's understanding is that the building owners, rather than Energex, are responsible for the location, design, installation and maintenance of electrical conduits.[420] Since the 2010/2011 flood, however, Energex has been working with the owners of basements that experienced flooding through conduits to seal the conduits using different products.[421] Energex's general manager said that its commercial and industrial substation manual will be updated once Energex has had greater experience with the new products currently being trialled;[422] an update to the manual is expected to be completed by the middle of 2012.[423]

The Australian Building Codes Board has developed a draft standard for the construction of buildings in flood hazard areas.[424] It is anticipated that the draft standard will be included in the 1 May 2013 version of the Building Code of Australia.[425] The draft code contains a standard that 'electrical conduits and cables installed below the FHL [flood hazard level] must be waterproofed or placed in waterproofed enclosures'.[426] For that provision to have any operation it will be necessary for councils to adopt a defined flood hazard level.[427] (See also chapter *9 Building controls.*)

There is a gap in responsibility for ensuring that conduits do not compromise the flood immunity of basements. Although steps are now being taken voluntarily, the Queensland Government should consider imposing a requirement to ensure that it is clear who is ultimately responsible for securing such conduits, including those installed after the initial construction of a building. The Commission has not heard detailed evidence on who should bear this responsibility. At present, responsibility for the design and maintenance of conduits falls on the building owner,[428] although there appears to be a sound argument that the distributor that uses the conduit should be responsible (or, at least, required to be closely involved) given that it has the expertise required to safely and effectively seal the conduits.

Recommendation

10.21 The Queensland Government should consider implementing mandatory requirements to ensure that all conduits for the purpose of providing electrical supply below the applicable defined flood level are sealed to prevent floodwaters from entering them or flowing into them.

10.4 Telecommunications infrastructure

Telecommunications services are crucial during disaster events for emergency service personnel and affected communities, but they are vulnerable. Breakdowns in telecommunications during natural disasters can result from lack of network coverage, power outages or damage to telecommunications infrastructure.[429]

Telecommunications providers ('carriers')[430] determine the extent of network coverage, which is usually dictated by commercial considerations.[431] The problem of power outages in the 2010/2011 floods was discussed in the Commission's interim report, as were the initiatives carriers adopted to deal with them: using generators, installing temporary mobile base stations, or re-routing telecommunications traffic to areas not affected by the power outage.[432]

The third cause of loss of telecommunications - damage to infrastructure - is particularly acute in flooding. Its extent will largely depend on two factors: where infrastructure is placed and carriers' approaches to the design and protection of their facilities. The first, the locating of telecommunications infrastructure, is guided by federal and state instruments.

10.4.1 The locating of telecommunications infrastructure

The installation of telecommunications infrastructure is regulated at the Commonwealth level by the *Telecommunications Act 1997*. The Act distinguishes between 'low-impact' facilities, temporary facilities for defence, and 'other' facilities.[433] Low impact facilities are defined in the *Telecommunications (Low-impact facilities) Determination 1997*:[434] they include small radio communications dishes,[435] antennae[436] and public payphones,[437] though the designation of some activities as low impact depends upon their proximity to residential, commercial, industrial and rural areas. For instance, an extension to a telecommunication tower less than five metres in height will only be designated as a low impact facility in industrial and rural areas, and not in residential or commercial areas.[438]

Low impact, temporary and defence-related facilities are exempt from state and territory planning laws. However, carriers must comply with the *Telecommunications Act 1997* and the *Telecommunications Code of Practice 1997*[439] when installing these facilities. The code of practice also requires that carriers follow industry codes and standards,[440] including the Communications Alliance's *Deployment of mobile phone network infrastructure* industry code.[441]

Section 5.1 of the industry code requires carriers to take a 'precautionary approach' when selecting a site.[442] Amongst other things, the precautionary approach requires that carriers consider whether a site is likely to be a 'community sensitive location': a residential area, or the vicinity of a child care centre, school, aged care centre, hospital or 'regional icon' (the last is not defined, and could mean anything).[443] The objective is to avoid such locations.

Facilities which do not fall within the 'low impact' category, or which are not temporary or defence-related facilities, are subject to development approval by councils.

Queensland's State Planning Policy 1/03 Guideline suggests that essential services infrastructure, including telecommunications facilities, be:

- placed above the defined flood level
- constructed to exclude floodwaters
- designed and constructed to resist hydrostatic and hydrodynamic forces as a result of inundation by a defined flood event.[444]

Since the State Planning Policy 1/03 Guideline is not binding, councils may decide whether to incorporate these suggested outcomes into their planning schemes. Thus, flood risk for telecommunications infrastructure may be approached differently by different councils.

By way of example, Brisbane City Council's planning scheme incorporates a telecommunication tower code (Chapter 5) and telecommunication towers planning scheme policy (Appendix 2). The code and policy require that towers do not constitute a safety hazard to aviation operations[445] and that sites be selected in an effort to minimise impacts on the surrounding environment and community,[446] though they do not take account of flood risk. Assessable development for telecommunications infrastructure may enliven other regulations in the Brisbane City Council planning scheme, which do consider flood risk.[447] However, the code and policy do not incorporate the suggested outcomes in the State Planning Policy 1/03 Guideline.

Where a carrier has been unable to secure development approval through a council,[448] it may apply to the Australian Communications and Media Authority for a facility installation permit.[449] This process is intended to ensure that there is a balance between the sometimes inconsistent aims of addressing community concerns and investing in infrastructure to meet demands for telecommunications services.[450] In considering a permit application, the Australian Communications and Media Authority must apply criteria[451] which require, amongst other things, that:

- where telecommunications facilities are proposed to be placed near communities, the community has been fully consulted and has agreed (wherever possible) to the placement of the facility, and
- alternative 'less sensitive' sites have been considered.

The combined effect of commonwealth, state and local regulation of the telecommunication industry means that carriers are encouraged to build telecommunications infrastructure away from residential and community use zones. Since residential and community use areas are generally situated outside the floodplain, a consequence of this approach has been that some telecommunications facilities have been built in areas susceptible to flooding. One carrier pointed out that the requirement under state and local regulations for base stations, in particular, to have low visual impact meant that they were often located in areas more susceptible to flood.[452]

The installation of telecommunications facilities involves an obvious tension between minimising their impact on the community and reducing the chance of their flooding.

Recommendation

10.22 Carriers, councils and the Australian Communications and Media Authority should take into account the risk of flooding when considering the placement of telecommunications facilities.

10.4.2 The design and protection of telecommunications infrastructure

Given the various (legitimate) reasons for installing telecommunications infrastructure outside residential and community use areas, it is inevitable that some telecommunications infrastructure will still have to be built on floodplains. In those circumstances, carriers need to make their facilities as flood-resilient as possible.

Optus selects sites for exchanges and fibre access nodes which are above the flood level that has an annual exceedance probability of one per cent.[453] It also attempts to place mobile base stations and transmission hubs above this level.[454] However, this is only possible where accurate flood data is available. Clearly wider availability of floods maps would assist it in doing so.[455]

Telstra takes various approaches to increasing the resilience of telecommunications infrastructure located in areas susceptible to flooding. These include elevating facilities above defined flood levels[456] and bolting steel plates to the walls of exchanges or wrapping them in plastic to prevent the intrusion of floodwaters.[457]

Telstra's St George exchange wrapped in plastic and sandbagged to protect it from floodwaters during the 2010/2011 floods
Source: Exhibit 215, Supplementary submission of Telstra, 8 April 2011, Annexure 1 [p9].

Telstra's CMUX unit at Rockhampton built on an elevated platform, so it was above floodwaters during the 2010/2011 floods
Source: Exhibit 215, Supplementary submission of Telstra, 8 April 2011, Annexure 1 [p12].

Carriers will, no doubt, continue their efforts to improve the resilience of telecommunications facilities against the impacts of flooding, with measures such as those identified in State Planning Policy 1/03 in mind. It is in their best interests, and those of emergency service personnel and the wider community, to ensure telecommunications services continue to function during disaster events.

10.5 Roads and rail

Road and rail infrastructure in Queensland was significantly affected by the 2010/2011 floods. Transport links are essential to all communities; this part of the Commission's report examines the response of transport authorities to the need to re-establish these links as quickly as possible after flooding. Possible improvements in flood immunity[458] are considered as an aspect of preparedness. The problem of properties isolated by the flooding of low-lying access routes is discussed in section *7.8 Anthills: Properties isolated by flooding of low-lying access routes*.

10.5.1 Roads

The development and upkeep of Queensland's network of major roads is the responsibility of the Department of Transport and Main Roads. This system of roads is referred to as the state-controlled road network.[459] Within this network, roads have a priority status assigned to them (from one to three), depending on a range of factors including their social and economic importance, freight and passenger traffic volumes, and strategic significance.[460] Thus, the Bruce Highway, unsurprisingly, has a priority status of one, although there are 111 priority one, 44 priority two and 71 priority three roads in Queensland.[461]

Priority levels guide the department's road development and investment programs.[462] They also helped to determine the department's response and recovery priorities following the widespread disruption of the network caused by the 2010/2011 floods.[463]

Queensland has over 33 000 kilometres of state-controlled roads. Over 9000 kilometres (or about 27 per cent) of the network were affected by the natural disasters of the 2010/2011 wet season.[464] In south-east Queensland, the road network sustained more damage than any other state asset during the floods.[465]

Flooded road at Jondaryan, January 2011 (photo courtesy G Cooke, Jondaryan District Residents Association)

Most priority one roads (including the Bruce, Warrego, Cunningham, New England, Leichhardt, Dawson, Capricorn, Gregory, Peak Downs and Landsborough Highways) were closed at a number of locations and for varying periods of time during the floods. In terms of the duration of closures, some of the worst affected places were:

- the Bruce and Capricorn Highways around Rockhampton (between 10 and 20 days)
- the Capricorn Highway east of Duaringa and west of Comet (between 10 and 20 days in each case)
- the Warrego Highway between Dalby and Chinchilla (between 10 and 20 days)
- the Leichhardt Highway north of Taroom (between 30 and 50 days) and around Theodore (between 20 and 30 days).[466]

The department's response to the floods involved a three-phase approach consisting of:

- the incident response phase, guided by the Road Network Incident Response Plan[467]
- the network recovery phase, guided by the Flood Recovery Phase Project Plan[468]
- the network restoration or reconstruction phase.[469]

Remedial roadworks undertaken during the initial two phases are not designed to achieve greater flood immunity; rather, they are meant to achieve the prompt resumption of safe vehicular use.[470]

The third, or restoration, phase involves longer term work to restore flood damaged roads to 'current engineering standards'.[471] While this implies some degree of improvement, as roads are to be restored not to their pre-existing state but to prevailing modern standards, it does not necessarily equate to improved flood immunity. Instead, opportunities to improve the 'resilience' and safety of the road network are identified and pursued should there be funding available to do so.[472]

The *Queensland Transport and Roads Investment Program 2011-12 to 2014-15* sets out the road and rail transport projects the department expects to complete in the coming four years. However, the document only identifies firm funding commitments for the first two years, in the case of projects funded by the Queensland Government, and for the first year for projects funded by the Commonwealth Government. After those timeframes, the funding allocations become indicative only.

A review of the investment program reveals that most of the roadworks being undertaken on sections of the priority one network that were affected by the 2010/2011 floods are directed to flood recovery (or reinstatement) works, rather than increasing immunity. Where enhancement of the network is contemplated, it is often for the purpose of catering for increased traffic volumes or improving road safety. For example:

Project location	Flood effects	Project
Capricorn Highway (Rockhampton to Duaringa)	Maximum duration of closure on road segment = 17 days[473]	Flood recovery works[474] Undertake miscellaneous works, install/replace signs[475] Construct overtaking lane/s, improve intersection/s[476]
Gregory Highway (Emerald to Clermont)	Maximum duration of closure on road segment = 9.6 days[477]	Flood recovery works[478] Install traffic signals, reseal bitumen[479]

The Commission understands that these works should be viewed in the broader context of the range of projects outlined in the investment program. Reducing road congestion while making provision for population growth (for example, by duplicating carriageways or developing mass transit systems such as busways) and increasing road safety (by widening road pavements and shoulders, improving road alignments, constructing overtaking lanes, upgrading intersections and roundabouts, installing traffic lights, constructing overpasses and rest areas, adding guardrails and better signage or improving access points on major roads) are recurrent themes in the spending priorities identified in the investment program.[480] None of these projects necessarily involves improvements being made to the flood immunity of the road network, but they remain critically important to its functioning.

According to the department's general manager of program delivery and operations, increasing the flood immunity of state-controlled roads is a longer term aim of the department, which would ordinarily be achieved 'only…as part of the [department's] normal infrastructure program'.[481] However, the Queensland Reconstruction Authority sought nominations from the department for projects which will increase road flood immunity to be funded as part of the Natural Disaster Relief and Recovery Arrangements. Six projects have been put forward by the department in response to the reconstruction authority's invitation.[482] A further eight projects, forming part of the department's normal infrastructure program, are intended to improve the road network's flood immunity.[483]

A review of these eight projects indicates that major ones, such as those affecting the Bruce Highway, involve significant expense and are very much long-term in nature. Section C of the Cooroy to Curra upgrade (from Traveston to Keefton Roads south of Gympie) is one part of a four stage upgrade to the Bruce Highway between Cooroy and Curra, which will involve an extensive re-alignment of the route and provide a four lane highway that bypasses Gympie. Section C is still in the planning stage.[484] Although the improvement in flood immunity expected to result from this project is not revealed by the information before the Commission, a part of this section of the highway was closed for five and a half days during the floods.[485] This upgrade is described as being one of Queensland's highest priority road projects.[486]

South of Rockhampton, the Bruce Highway crosses the Yeppen floodplain. During the 2010/2011 floods, this section of the highway was closed as a result of inundation for about two weeks, cutting access to Rockhampton by this route. The highway at this point will currently escape inundation in a flood that has an average recurrence interval of 20 years or less. It is expected that the upgrade, which is currently in the planning and preliminary design phase, will ensure it is not cut in floods with an average recurrence interval up to 100 years.[487] While the Bruce Highway upgrade strategy indicates that the Yeppen floodplain upgrade should occur within the next five to 10 years, it is possible that this could be delayed until 2021 – 2031.[488]

Yellow Gin Creek, which passes under the Bruce Highway between Bowen and Ayr, is on the southern extremity of the Burdekin River floodplain. The location will be inundated with an average recurrence interval of more than 2 years. A business case in support of an upgrade has been prepared for submission to the Commonwealth Government. The proposal involves building a new bridge with higher approaches to replace the existing concrete floodway; the new bridge will be above the level of a flood with an average recurrence interval of 20 years. No higher level could be achieved because of the increased risk of flooding to the railway line located upstream.[489]

Funding availability and the need to minimise the risk of causing upstream flooding are the two greatest constraints on achieving greater flood immunity across the road network. The budgetary constraints are the product of the significant financial cost that often accompanies projects incorporating improved flood immunity and the vast range of other projects that have a legitimate claim on the public purse, such as those which are designed to increase network efficiency, by reducing congestion, and improve road safety.

For flood immunity improvements to the existing road network, these pressures are acute. Whether they are less so for new roads in so-called 'greenfield areas' is perhaps doubtful. However, the opportunity to construct roads to an optimal level of flood immunity, even taking into account potential upstream effects, may be greater.

Recognising the competing considerations which underlie decisions as to what roadworks should be undertaken, the Commission, while emphasising the importance of maximising flood immunity for all roads, particularly those in new transport corridors, does not consider it appropriate to make any recommendation as to the priority to be given to that aim.

10.5.2 Rail

Queensland Rail

Queensland Rail owns and operates rail infrastructure in all parts of the state except for the central Queensland coalfields. It also operates passenger services throughout the state.

Queensland Rail has a corporate plan which includes various risk identification and mitigation strategies designed to protect its infrastructure from damage which may result in a loss of services. This plan resulted in the development of the company's General Risk Framework and the Safety Risk Framework. The frameworks require risks to be identified and cross-referenced to safety manuals with mechanisms for responding to the risks in question.[490]

At a practical level, these processes saw Queensland Rail staff in Toowoomba close the Toowoomba range line the day before it was washed away by flash flooding. The line had previously been identified as a location at risk of damage in the event of flooding. When faced with the prediction of a major storm the following day, Queensland Rail closed the line.[491] It seems that as a result of rail lines at risk from flooding being identified in this way, no trains were running on lines when they became flooded and no Queensland Rail rolling stock was damaged or derailed.[492]

Other steps taken included moving rolling stock away from areas of possible flooding[493] and removing electric points machines from rail yards that were likely to be flooded, such as the one located in Rockhampton.[494] Queensland Rail has acknowledged, however, that in some cases it only managed to stow its rolling stock safely because of the local knowledge of its staff, and not because of established risk management procedures. It has resolved to learn from this experience.[495]

The 2010/2011 floods affected over 3000 kilometres of Queensland Rail track across the state in some way.[496]

The most severe disruption occurred on the West Moreton line as a result of the track largely being washed away at Spring Bluff. This was the only part of Queensland Rail's network that was destroyed as a result of the floods. However, the Toowoomba range rail corridor, the worst-affected part of the West Moreton line, was entirely rebuilt within 12 weeks.[497]

In Brisbane, the passenger network was almost entirely operational within six hours of the flood, and all services had resumed by 10.00 am on Thursday, 13 January 2011, with the exception of those on the Ipswich line between Darra and Rosewood. This part of the network became operational again on Wednesday, 19 January 2011.[498]

Queensland Rail seeks to make its network infrastructure 'flood free' where possible. This means building it above the 1 in 100 flood level. Where it is not cost effective to achieve flood free status, Queensland Rail tries to make its infrastructure 'flood-proof' to the greatest possible extent. Even if floodwaters submerge its infrastructure, it can be promptly recommissioned, as it was designed to withstand water flows associated with a range of flood events. The Brisbane Airport line, which sits on concrete pylons above the floodplain, is designed to be flood free. Achieving this across the whole of the state's rail network is simply not viable; however, it is viable for Queensland Rail to undertake flood-proofing. This would see the flood-proofed lines requiring only minor works after a flood to restore them to operational capacity in a relatively short time.[499]

Queensland Rail's priority after floodwaters had receded was to resume rail services as quickly as possible in the affected areas. In reality, this meant restoring the network to its former 'flood-proof' status without making improvements to the flood immunity of any of its railways. The one exception to this approach was in Emerald, where 10 additional pipes were installed under the railway line to prevent floodwaters from overflowing and causing scouring. No other specific improvements were seen as being necessary, on either the metropolitan or the regional track systems, including on the West Moreton line running through the Lockyer Valley from Rosewood to Toowoomba.[500]

Since the floods, Queensland Rail has moved some critical equipment to higher ground, particularly in the Brisbane metropolitan area. At Goodna railway station, on the Ipswich line, the communication and signalling equipment rooms have both been raised a metre above the highest known flood level at that location.[501] The Commission endorses these measures.

QR National

QR National operates approximately 2300 kilometres of largely dedicated and purpose-built heavy haul rail infrastructure known as the Central Queensland Coal Network.[502]

Flooding occurred in various parts of this network between December 2010 and early January 2011.[503] QR National's response to these events included:

- initiating its safety plan for large-scale disasters
- purchasing specialised meteorological advice to guide the making of operational decisions
- moving locomotives and wagons to higher ground
- establishing a flood recovery taskforce to oversee the recovery effort.[504]

These steps were both appropriate and effective, with no damage being sustained to rolling stock.[505]

Comet River overflow (photo courtesy QR National)

Parts of the rail network itself were damaged when flooding occurred and were closed until necessary repairs could be carried out. Worst affected were:

- The Moura System – after a temporary closure in early December 2010 due to heavy rainfall and flash flooding, the system was closed again between 27 December 2010 and 6 January 2011 as a result of flooding. The system reopened with speed restrictions to protect the track while repairs were continuing, and became fully operational on 13 January 2011.[506]
- The Blackwater System – a temporary closure also occurred on this system in early December, followed by a more lengthy closure between 27 December 2010 and 19 January 2011 as a result of extensive flooding. Operations were progressively re-instated between 19 and 26 January 2011, except in the case of the Rolleston spur line, which was the most severely damaged part of QR National's network. This part of the system became fully operational again on 8 March 2011.[507]

Repairs to QR National's rail network were completed within three to six weeks, enabling operations to return to full capacity. However, QR National found that it had more train services available to haul coal than were required, because of a fall in production from the mines.[508]

QR National uses Queensland Rail's West Moreton Line to haul grain, general freight and coal from areas west and south-west of Brisbane. Damage to this line on the Toowoomba Range caused the longest disruption to QR National's freight services. In this instance, road transport was used in an attempt to meet haulage obligations.[509]

QR National's rail network in central Queensland is built for tropical environmental conditions.[510] This does not mean that the system is immune from inundation; rather, it is designed to withstand the effects of flooding so that repairs can be effected quickly. In most areas of the network, track structure remained intact, with only the ballast being displaced. This enabled the main line of the Blackwater System to be reopened to traffic (without signalling) only seven days after floodwaters had receded.[511]

Recommendation

10.23 Queensland Rail and QR National should continue to investigate opportunities for increasing the flood resilience of their networks, including raising the height of critical equipment.

(Endnotes)

1 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p7: para 28].

2 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p6: para 27].

3 Exhibit 865, Statement of Robin Lewis, 4 May 2011 [p4: para 20].

4 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p7: para 35]; Appendix A.

5 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p8: para 40]; Appendix C.

6 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p8: para 42].

7 Exhibit 289, Statement of Colin Jensen, 19 April 2011, Attachment CDJ-28.

8 Exhibit 289, Statement of Colin Jensen, 19 April 2011, Attachment CDJ-16; CDJ-27.

9 Exhibit 289, Statement of Colin Jensen, 19 April 2011, Attachment CDJ-16 [p528].

10 Exhibit 864, Statement of Paul Belz, 25 October 2011 [p2: para 7].

11 Exhibit 863, Statement of Paul Belz, 21 October 2011 [p2: para 8-9].

12 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p8: para 44-45].

13 Exhibit 863, Statement of Paul Belz, 21 October 2011 [p3: para 10-13].

14 Transcript, Diane Robertson, 3 October 2011, Brisbane [p3476: line 10].

15 Exhibit 863, Statement of Paul Belz, 21 October 2011 [p2: para 3-6].

16 Transcript, Paul Belz, 25 October 2011, Brisbane [p4268: line 13].

17 Statement of John Kersnovski, 16 September 2011 [p2].

18 Statement of John Kersnovski, 16 September 2011 [p2].

19 Exhibit 777, Statement of Ronald Smith, 12 September 2011 [p2, 5].

20 Exhibit 777, Statement of Ronald Smith, 12 September 2011 [p5]; Exhibit 770, Statement of Robert Savage, 12 September 2011 [p9, 11].

21 Statement of Mark Pitt, 12 September 2011 [p4: para 6]; Exhibit 777, Statement of Ronald Smith, 12 September 2011 [p2].

22 Exhibit 777, Statement of Ronald Smith, 12 September 2011 [p3].

23 Exhibit 270, Statement of Scott Norman, 1 April 2011 [p5].

24 Exhibit 463, Statement of Collin Head, 5 April 2011 [p12].

25 Exhibit 463, Statement of Collin Head, 5 April 2011, Attachment 6 [p43].

26 Exhibit 470, Statement of Desmond Howard, 1 April 2011 [p3].

27 Exhibit 775, Statement of Michael Clerke, 18 March 2011 [p13: para 84].

28 Exhibit 775, Statement of Michael Clerke, 18 March 2011 [p13: para 84].

29 Exhibit 750, Statement of Goodwin McLeod, 29 September 2011 [p3: para 19].

30 Transcript, Goodwin McLeod, 10 October 2011, Bundaberg [p3858: line 45].

31 Statement of Phil Berting, 25 March 2011 [p11].

32 Statement of Phil Berting, 25 March 2011 [p10].

33 Transcript, Robert Fredman, 13 October 2011, Gympie [p4058: line 33].

34 Transcript, Robert Fredman, 13 October 2011, Gympie [p4058: line 56].

35 Transcript, Thomas Thomas, 13 October 2011, Gympie [p4082: line 35; p4084: line 21]; Exhibit 823, Statement of Thomas Thomas, 28 September 2011 [p5: para 14].

36 Exhibit 823, Statement of Thomas Thomas, 28 September 2011 [p5: para 15].

37 Statement of Jonathan Black, 16 September 2011 [p2: para 6]; Annexure JB-01.

38 Exhibit 249, Statement of Rodney Ferguson, 14 April 2011 [p3: para 27].

39 Exhibit 683, Statement of Bryan Ottone, Central Highlands Regional Council, 6 September 2011 [p4]; Exhibit 670, Statement of Luke Lankowski, 1 September 2011 [p7: para 8.4.2].

40 Exhibit 683, Statement of Bryan Ottone, Central Highlands Regional Council, 6 September 2011 [p5].

41 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p5: para 22].

42 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p5: para 24].

43 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p5: para 22].

44 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p5: para 20-21].

45 Exhibit 866, Statement of Robin Lewis, 12 October 2011 [p5: para 20].

46 State Planning Policy 1/03: *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*, Annex 4 [A4.2].

47 State Planning Policy 1/03: *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide,* Annex 3 [A3.1 – A3.2].

48 State Planning Policy 1/03 : *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*, Annex 5 [A5.1 – A5.2].

49 State Planning Policy Guideline 1/03 : *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* [6.19].

50 Exhibit 766, Statement of Andrew Fulton, 1 September 2011 [p21: para 9.1.1].

51 Exhibit 766, Statement of Andrew Fulton, 1 September 2011 [p22: para 9.1.1.2].

52 Exhibit 766, Statement of Andrew Fulton, 1 September 2011 [p23: para 9.1.2].

53 Exhibit 766, Statement of Andrew Fulton, 1 September 2011 [p23: para 9.1.3].

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321 Submission from Ergon Energy, 11 March 2011 [p8: para 5.4].

322 As at 11 March 2011. Submission of Ergon Energy, 11 March 2011 [p8: para 5.5].

323 Submission from Ergon Energy, 11 March 2011 [p8: para 5.5].

324 Submission from Ergon Energy, 11 March 2011 [p8: para 5.4].

325 Submission from Ergon Energy, 11 March 2011 [p8: para 5.6].

326 Submission from Ergon Energy, 11 March 2011 [p8: para 5.6].

327 Transcript, Chris Arnold, 13 May 2011, Brisbane [p1967: line 7].

328 Item 9, Table 5, Schedule 4, *Sustainable Planning Regulation 2009.*

329 Section 10, *Sustainable Planning Regulation 2009.*

330 Section 232(2), *Sustainable Planning Act 2009.*

331 Sections 235(1) and (2), *Sustainable Planning Act 2009.*

332 Sections 8 and 12(3)(c), *Electricity Act 1994.*

333 Statement of Andrea Kenafake, 21 November 2011 [p8: para 35].

334 Section 202, *Sustainable Planning Act 2009*. Use of designated land contrary to a requirement is an offence under section 582(b)(ii).

335 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4282: line 19].

336 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4282: line 18].

337 Submission from Energex Limited, Planning Term of Reference [p5: para 32].

338 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4287: line 15].

339 State Planning Policy 1/03 Guideline: *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide*, Appendix 9.

340 Section 82, *Electricity Act 1994.*

341 Submission from Energex Limited, Planning Term of Reference, [p5: para 31].

342 Statement of Chris Arnold, 21 November 2011 [p2: para 13-15].

343 Statement of Chris Arnold, 21 November 2011 [p2: para 9].

344 Statement of Chris Arnold, 21 November 2011 [p2: para 10-11].

345 Statement of Damien Walker, 16 December 2011 [p2: para 5].

346 Statement of Donald Rivers, 12 December 2011, DR-1 [p18].

347 Statement of Chris Arnold, 21 November 2011 [p2: para 17].

348 Statement of Chris Arnold, 21 November 2011 [p3: para 18].

349 Statement of Chris Arnold, 21 November 2011 [p3: para 19-20].

350 Statement of Andrea Kenafake, 21 November 2011, AMK-07.

351 Statement of Andrea Kenafake, 21 November 2011 [p4: para 16] , AMK-09.

352 Statement of Chris Arnold, 21 November 2011 [p3: para 22-24].

353 Statement of Chris Arnold, 21 November 2011[p3: para 22].

354 Statement of Donald Rivers, 12 December 2011, DR-9 [p1].

355 Statement of Donald Rivers, 12 December 2011, DR-10, DR-11.

356 Statement of Donald Rivers, 12 December 2011, DR-11.

357 Statement of Chris Arnold, 21 November 2011 [p3: para 26].

358 Statement of Chris Arnold, 21 November 2011 [p3: para 27].

359 Statement of Chris Arnold, 21 November 2011 [p3: para 28].

360 Statement of Chris Arnold, 21 November 2011 [p4: para 29].

361 Statement of Chris Arnold, 21 November 2011 [p5: para 43].

362 Statement of Chris Arnold, 21 November 2011 [p5: para 41-42].

363 Statement of Chris Arnold, 21 November 2011 [p5: para 44].

364 Statement of Chris Arnold, 21 November 2011 [p5: para 44].

365 Statement of Chris Arnold, 21 November 2011 [p6: para 51].

366 Statement of Chris Arnold, 21 November 2011 [p6: para 55-56].

367 Statement of Neil Lowry, 24 November 2011 [p3: para 2-4].

368 Statement of Neil Lowry, 24 November 2011, NL-4.

369 Statement of Neil Lowry, 24 November 2011 [p4: para 7].

370 Statement of Neil Lowry, 24 November 2011 [p7: para 22].

371 Statement of Neil Lowry, 24 November 2011 [p8: para 28].

372 Statement of Neil Lowry, 24 November 2011, NL-7.

373 Statement of Neil Lowry, 24 November 2011 [p9: para 37].

374 Statement of Neil Lowry, 24 November 2011 [para 40].

375 Statement of Neil Lowry, 24 November 2011 [para 43].

376 Submission, Energex Limited, Planning Term of Reference [p7: para 54; p8: para 58].

377 Transcript, Chris Arnold, 13 May 2011, Brisbane [p1965: line 19].

378 Transcript, Chris Arnold, 13 May 2011, Brisbane [p1965: line 31].

379 Statement of Neil Lowry, 24 November 2011 [p9: para 35].

380 Transcript, John McLeod, 4 October 2011, Brisbane [p3550: line 40].

381 Transcript, John McLeod, 4 October 2011, Brisbane [p3551: line 17].

382 Transcript, John McLeod, 4 October 2011, Brisbane [p3551: line 23; p3552: line 1].

383 Transcript, John McLeod, 4 October 2011, Brisbane [p3552: line 36].

384 Transcript, John McLeod, 4 October, Brisbane [p3552: line 50].

385 Transcript, John McLeod, 4 October 2011, Brisbane [p3553: line 36]; Exhibit 701, Statement of John McLeod, [p3: para 6].

386 Transcript, John McLeod, 4 October 2011, Brisbane [p3553: line 4].

387 Transcript, John McLeod, 4 October 2011, Brisbane [p3554: line 44].

388 Transcript, John McLeod, 4 October [p3554: line 51 - p3555: line 10].

389 Exhibit 629, Statement of Cassandra Sun, 14 September 2011 [p3: para 9].

390 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3463: line 47 – p3464: line 7].

391 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3463: line 40].

392 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3464: line 1].

393 See in particular Section 59, *Electricity Regulation 2006*.

394 State Planning Policy 1/03: *Mitigating the Adverse Effects of Flood, Bushfire and Landslide*, Annex 3, A4.2.

395 Table 5, Brisbane City Council Temporary Local Planning Instrument 01/11.

396 Exhibit 847, Ipswich City Council Temporary Local Planning Instrument 01/2011, Part 7, 7.2, Attachment 2.

397 Queensland Reconstruction Authority, Planning for stronger, more resilient electrical infrastructure, 2011 [p15].

398 Submission, Energex Limited, Planning Term of Reference [p5: para 26].

399 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4287: line 45].

400 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4287: line 45].

401 Submission of Energex Energy, Planning Term of Reference [p24: para 13].

402 Submission of Energex Energy, Planning Term of Reference [p17: p24: para 13].

403 Submission of Energex Energy, Planning Term of Reference [p24: para 13].

404 Submission of Energex Energy, Planning Term of Reference [p24: para 15-20].

405 Exhibit 867, Statement of Chris Arnold, 6 October 2011 [p1: para 6-7].

406 Exhibit 867, Statement of Chris Arnold, 6 October 2011 [p1: para 8].

407 Exhibit 688, Statement of Lynn de Lange, 13 September 2011 [p1: para 3].

408 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4293: line 38].

409 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3464: line 16].

410 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3464: line 19].

411 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3464: line 35].

412 Transcript, Lynn de Lange, 3 October 2011, Brisbane [p3464: line 27].

413 Transcript, Cassandra Sun, 27 September 2011, Brisbane [p3211: line 35].

414 Transcript, Cassandra Sun, 27 September 2011, Brisbane [p3211: line 57 - p3212: line 7].

415 Exhibit 596, Statement of Paul Cassels, 14 September 2011 [p1: para 2].

416 Exhibit 596, Statement of Paul Cassels, 14 September 2011 [p2: para 5].

417 Transcript, Paul Cassels, 22 September 2011, Brisbane [p3022: line 44].

418 Exhibit 867, Statement of Chris Arnold, 6 October 2011 [para 18].

419 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4290: line 39].

420 Exhibit 867, Statement of Chris Arnold, 6 October 2011 [para 18].

421 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4290: line 47].

422 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4290: line 47].

423 Transcript, Chris Arnold, 25 October 2011, Brisbane [p4291: line 2].

424 Australian Building Codes Board, Draft Standard for Construction of Buildings in Flood Hazard Areas, Version 7, October 2011.

425 Exhibit 666, Statement of Glen Brumby, 15 September 2011 [p9: para 36].

426 Australian Building Codes Board, Draft Standard for Construction of Buildings in Flood Hazard Areas, Version 7, October 2011, 2.12.2(b).

427 Exhibit 666, Statement of Glen Brumby, 15 September 2011 [p11: para 48].

428 Exhibit 867, Statement of Chris Arnold, 6 October 2011 [p3: para 18]; Transcript, Chris Arnold, 25 October 2011, Brisbane [p4293: line 4].

429 Exhibit 215, Supplementary submission of Telstra, 8 April 2011 [p9: para 41].

430 While both 'carriers' and 'carriage service providers' provide telecommunications services to the public, only carriers install and own telecommunications network infrastructure (Australian Communications and Media Authority, Carrier and service provider requirements, 2011).

431 Exhibit 215, Supplementary submission of Telstra, 8 April 2011 [p8: para 37]; Exhibit 214, Supplementary submission of Optus, undated [p2: para 4].

432 Queensland Floods Commission of Inquiry, *Interim Report*, 2011 [p221].

433 Under section 7 of the *Telecommunications Act 1997*, a facility is any part of the infrastructure of a telecommunications network or any line, equipment, apparatus, tower, mast, antenna,

tunnel, duct, hole, pit, pole or other structure or thing used, or for use, in or in connection with a telecommunications network. A telecommunications network means a system, or a series of systems, that carries or is capable of carrying, communications by means of guided and/or unguided electromagnetic energy.

434 Schedule 3 Division 3 Section 6(3), *Telecommunications Act 1997* (Cth).

435 Schedule, part 1(5A), *Telecommunications (Low-impact facilities) Determination 1997*.

436 Schedule, part 1(4), *Telecommunications (Low-impact facilities) Determination 1997*.

437 Schedule, part 5(1-2), *Telecommunications (Low-impact facilities) Determination 1997*.

438 Schedule, part 1(9), *Telecommunications (Low-impact facilities) Determination 1997*.

439 Schedule 3, Division 5, Section 15(2), *Telecommunications Act 1997* (Cth).

440 These industry codes and standards must be registered with the Australian Communications and Media Authority (ACMA).

441 Communications Alliance (formerly Australian Communications Industry Forum), *Industry code ACIF C564:2004 Deployment of mobile phone network infrastructure*, 2005.

442 Communications Alliance (formerly Australian Communications Industry Forum), *Industry code ACIF C564:2004 Deployment of mobile phone network infrastructure*, 2005 [p12: para 5.1].

443 Communications Alliance (formerly Australian Communications Industry Forum), *Industry code ACIF C564:2004 Deployment of mobile phone network infrastructure*, 2005 [p12: para 5.1.4(c-d)].

444 State Planning Policy 1/03 Guideline, *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* [p59: para 5.1-5.2].

445 Brisbane City Council, City Plan 2000*,* 2011 [p253-254].

446 Brisbane City Council, City Plan 2000, 2011, Appendix 2 [p169-171].

447 For instance, assessable development for telecommunications infrastructure may also enliven the Brisbane City Council's Subdivision and Development Guidelines. Flood risk may be considered under Chapter 1 of the guidelines, though they do not recommend a specific flood level for communication network facilities (which are defined as a type of 'community infrastructure') and only require that development proponents ensure that the infrastructure is 'optimally located and designed to achieve suitable levels of service' (Brisbane City Council, Subdivision and Development Guidelines, 2008, Chapter 1 [p6]).

448 Australian Communications and Media Authority, Guide to applying for a facility installation permit, 2007 [p2].

449 Schedule 3 Division 6 section 21(1), *Telecommunications Act 1997* (Cth).

450 Australian Communications and Media Authority, Guide to applying for a facility installation permit, 2007 [p2].

451 Schedule 3 Division 6 section 27(1), *Telecommunications Act 1997* (Cth).

452 Exhibit 213, Submission of Optus, 4 April 2011 [p11: para 7.3].

453 Exhibit 213, Submission of Optus, 4 April 2011 [p11: para 7.1].

454 Exhibit 213, Submission of Optus, 4 April 2011 [p11: para 7.2].

455 Exhibit 213, Submission of Optus, 4 April 2011 [p11: para 7.4].

456 Exhibit 215, Supplementary submission of Telstra, 8 April 2011 [p11: para 49-50].

457 Exhibit 215, Supplementary submission of Telstra, 8 April 2011 [p11: para 50].

458 The term "immunity" is used in a relative sense. For example, a road that is immune to a 1% AEP flood would not be immune to a 0.5% AEP flood. Further works might be undertaken on such a road to improve its immunity so that it was immune to a 0.5% AEP flood.

459 Statement of Miles Vass, 8 September 2011 [p2: para 8-9].

460 Statement of Miles Vass, 8 September 2011 [p2: para 10-11]; Attachments B and C.

461 Statement of Miles Vass, 8 September 2011 [p3: para 13]; Attachment D.

462 Statement of Miles Vass, 14 November 2011 [p3: para 11-12].

463 Statement of David Stewart, 18 April 2011 [p6: para 41, 44].

464 Queensland Transport and Roads Investment Program 2011-12 to 2014-15 [p ii].

465 Queensland Transport and Roads Investment Program 2011-12 to 2014-15 [p30].

466 Statement of Miles Vass, 8 September 2011, Attachments E and F.

467 Statement of David Stewart, 18 April 2011 [p6-7: para 41-43] and Attachments D and E; Statement of Miles Vass, 8 September 2011 [p3: para 15].

468 Statement of David Stewart, 18 April 2011 [p7-9: para 44-53] and Attachment G; Statement of Miles Vass, 8 September 2011 [p4: para 15].

469 Statement of David Stewart, 18 April 2011 [p9: para 54-56]; Statement of Miles Vass, 8 September 2011 [p4: para 15].

470 Statement of Miles Vass, 8 September 2011 [p4: para 15].

471 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p30].

472 Statement of Miles Vass, 8 September 2011 [p4: para 15]; Statement of Emma Thomas, 4 May 2011 [p7: para 28-29].

473 Statement of Miles Vass, 8 September 2011, Attachment F, road segment 16A [p10].

474 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p118].

475 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p123].

476 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p125].

477 Statement of Miles Vass, 8 September 2011, Attachment F, road segment 27B [p12].

478 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p117].

479 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p124].

480 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p29-30, 51-52, 67-68, 83-84, 95-96, 115-116, 131-132, 145-146, 159-160, 173-174, 187-188].

481 Statement of Miles Vass, 8 September 2011 [p4: para 16].

482 Statement of Miles Vass, 8 September 2011 [p4-5: para 17-20]; Statement of Miles Vass, 14 November 2011 [p3: para 13-14].

483 Statement of Miles Vass, 8 September 2011 [p5: para 21-22]; Attachment G.

484 Statement of Miles Vass, 8 September 2011 [p5: para 22]; Attachment G [p3]; Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p95, 100].

485 Statement of Miles Vass, 8 September 2011 [p3: para 14(a)]; Attachment E, Map – Flooding of Priority 1 Road Network – Duration of Closure, 1 December 2010 to 30 April 2011; Attachment F, road segment 10A [p9].

486 Queensland Transport and Roads Investment Program 2011-21 to 2014-15 [p95].

487 Statement of Miles Vass, 8 September 2011 [p5: para 22]; Attachment G [p1].

488 Bruce Highway Upgrade Strategy – July 2011 [p16]; Statement of Amanda Yeates, 14 November 2011 [p3: para 9-11]; Attachment B.

489 Statement of Miles Vass, 8 September 2011 [p5: para 22]; Attachment G [p3].

490 Response to Requirement to Provide Information, Greg Ford, 25 March 2011, Schedule 3 [p85-87].

491 Response to Requirement to Provide Information, Greg Ford, 25 March 2011, Schedule 3 [p87-88]; Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning, preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p47-50].

492 Response to Requirement to Provide Information, Greg Ford, 25 March 2011, Schedule 3 [p88: 3.2(b)].

493 Response to Requirement to Provide Information, Greg Ford, 25 March 2011, Schedule 4 [p91].

494 Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning, preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p32].

495 Response to Requirement to Provide Information, Greg Ford, 25 March 2011, Schedule 4 [p91]; Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning, preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p340: para (e)].

496 Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning,

preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p9].

497 Statement of Graham Brown, 18 October 2011 [p20: para 75; p21: para 78]; Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning, preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p10].

498 Greg Ford and Theresa Timmins, Queensland Rail, Review and debrief report into the planning, preparation and response by Queensland Rail – Queensland floods and Cyclone Yasi, September 2011 [p10].

499 Statement of Graham Brown, 18 October 2011 [p7: para 35; p18-19: para 68-69].

500 Statement of Graham Brown, 18 October 2011 [p18: para 66; p19: para 70-71; p20-21: para 74-77].

501 Statement of Graham Brown, 18 October 2011 [p17: para 64c] and Annexure 5 [p254].

502 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p5].

503 Exhibit 1014, Statement of Martin Moore, 4 April 2011, Appendix 1e [p24].

504 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p13-15, 19]; Statement of Martin Moore, 18 November 2011 [p7].

505 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p19].

506 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p8].

507 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p9]; Appendix 1f [p25-26].

508 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p7-8, 9].

509 Exhibit 1014, Statement of Martin Moore, 4 April 2011 [p10].

510 Statement of Martin Moore, 18 November 2011 [p5-6].

511 Statement of Martin Moore, 18 November 2011 [p19].