SUBMISSIONS FOR STATE OF QUEENSLAND

04 APRIL 2011

Department of Environment and Resource Management (DERM)

C. All aspects of the response to the 2010/2011 flood events, particularly measures taken to inform the community and measures to protect life and private and public property (including immediate management, response and recovery; resourcing, overall coordination and deployment of personnel and equipment; adequacy of equipment and communications systems; and the adequacy of the community's response)

The DERM provided both general and specific flood response commentary in Submission 1 at Parts C, D and E.

Draft Protocol for the Communications of Flooding Information for the Brisbane River Catchment

In the second half of 2010, DERM participated in the development of the draft "Protocol for the Communication of Flooding Information for the Brisbane River Catchment – including Floodwater Releases from Wivenhoe and Somerset Dams". Emergency Management Queensland (EMQ) within the Department of Community Safety is the lead agency for the development of the draft communications protocol. Other participants in the development of the draft communications protocol include the Department of the Premier and Cabinet, Queensland Police Service, Seqwater, SEQ Water Grid Manager, Bureau of Meteorology (BOM), Brisbane City Council, Somerset Regional Council and Ipswich City Council.

The draft communications protocol details the arrangements to be followed by the Brisbane City Council, Ipswich City Council and Somerset Regional Council, Queensland Government agencies and BOM. The object of the Protocol is to ensure

the provision of consistent and robust information to the community concerning potential flooding impacts for the Brisbane River catchment, including release of floodwater from Wivenhoe and Somerset Dams.

The following are the key parts that apply to DERM:

(a) "In the case of floodwater release, the SEQ Water Grid Manager will alert the Director-General (DG) of the Department of Community Safety (DCS), DG Department of Environment and Resource Management (DERM), and the local governments.";

(b) "DG DERM will inform the Minister for Natural Resources, Mines and Energy."; and

(c) "Department of Environment and Resource Management (DERM) consults with the stakeholders prior to the approval of any updates to the Flood Mitigation Manual. The DERM also approves any necessary variations to the strategies in the manual if required during the course of a flood event."

The draft communications protocol was not finalised prior to the flood events in Brisbane and Ipswich in January 2011. However, given BOM's predictions for the summer storm and cyclone season, on 22 November 2010 the Premier of Queensland wrote to the mayors of Brisbane, Ipswich and Somerset proposing that the draft communications protocol be implemented on an interim basis pending its finalisation and formal sign-off by the parties.

The draft communications protocol is now being reviewed.

D. The measures to manage the supply of essential services such as power, water and communications during the 2010/2011 flood events

Water and sewerage providers

The DERM regulates Queensland's water and sewerage services. Chapter 2 of the *Water Supply (Safety and Reliability) Act 2008* (the Water Supply Act) was specifically developed to protect Queensland's communities from the consequences of

loss of essential services. The DERM works with urban and rural water supply and sewerage service providers to maintain or improve service standards and safety, while seeking to lower the cost of providing those services.

The regulatory framework is based around the fundamental principles that service providers:

(a) Set their own operational standards (operation and renewal strategy); and
(b) Are solely responsible for the day-to-day provision of water supply and sewerage services, i.e. DERM has no direct involvement in the delivery of the services.

The Water Supply Act requires that drinking water service providers must monitor water quality (currently for *E.* Coli and fluoride) in accordance with the Public Health Regulation 2005 and continue any other water quality monitoring in place prior to the commencement of the Water Supply Act. Drinking water service providers must also report to DERM any detection of *E. Coli* and exceedences of health guideline values in the Australian Drinking Water Guidelines found as a result of this monitoring. The Australian Drinking Water Guidelines health guideline values have been adopted by DERM in addition to the requirement of the Public Health Regulation 2005.

The DERM regulates discharge licence conditions/limits for sewerage, Strategic Asset Management Plans (SAMP), System Leakage Management Plans (SLMP) and Drinking Water Quality Management Plans (DWQMP).

Water supply and sewerage providers which are not required to be registered under the Water Supply Act are not regulated by DERM. These providers include bodies corporate, holiday resorts, mining operations and caravan parks.

The DERM sent an Advisory Information bulletin (a copy of which is attached and marked as '**DERM-01**') by email at 9:24 am on 24 December 2010 to all local governments reminding them of the importance of ensuring appropriate management of water quality during times of adverse weather condition and when usual resources such as laboratories and Council staff were not available.

Where test results indicated healthy drinking water quality parameters were exceeded during the flood events, the water service provider was required to ring a 1300 telephone number to report the test results. The DERM then liaised with Queensland Health and either DERM or Queensland Health then contacted the water service provider to have the matter rectified.

The DERM personnel attended meetings with the State Disaster Coordinator on 30 and 31 December 2010 amongst others, which involved EMQ (State Disaster Coordinator), Queensland Health (QH) and Local Government Association of Queensland (LGAQ). DERM's role was identified as providing technical support for essential water and sewage supplies.

It was initially agreed on 30 December 2010 that LGAQ would contact flood affected local councils to obtain information from councils on the status of flood affected water, sewerage and waste facilities. Following discussions with LGAQ, DERM commenced providing daily reports from 4 January 2011 for the first two weeks and subsequently on a weekly basis. The DERM contacted councils about the issues associated with water and sewerage services being provided. Currently DERM is contacting councils on a fortnightly basis as permanent infrastructure repairs are being implemented over 3, 6 and 12 month timeframes.

Where a council's services were interrupted, DERM telephoned the council representative to find out what actions were being undertaken to rectify the situation and when services would be restored. DERM also advised councils that if they needed assistance (for example equipment, staff, chemicals) that this could be facilitated and that requests should be coordinated through the Local District Disaster Management Group.

The DERM was not requested by councils to provide assistance or technical advice.

A chronological history of the 2010/11 flood event for water supply and sewerage damage for all councils outside south east Queensland as at 9 March 2011 is attached and marked as '**DERM-02**'. From time to time, DERM checked and reported on

specific communities. DERM also provided EMQ with technical advice on water supply and sewerage matters as required.

During the floods in south east Queensland, DERM personnel took part in a number of teleconferences involving the south east Queensland water entities (Water Grid Manager, Seqwater, Allconnex, Queensland United Utilities and Unity Water).

Situation reports have been provided to DERM's Executive Management Group, key internal departmental officers, the office of the Minister for Environment and Natural Resources, Queensland Reconstruction Authority and Department of the Premier and Cabinet. A copy of the most recent report is attached and marked as '**DERM-03**'.

From 5 to 21 January 2011, the situation reports on the SEQ floods were produced on a daily basis during the response phase. From 27 January to 14 February 2011 twice weekly situation reports were produced during the recovery phase. From 17 February 2011 up to the present, weekly reports (including during Cyclones Anthony and Yasi) were and are still being produced. The information in these reports regarding water and sewage treatment plans and dam levels in south east Queensland is provided by south east Queensland water entities (Water Grid Manager, Seqwater, Allconnex, Queensland United Utilities and Unity Water). The information for the remainder of the State is provided by DERM.

The DERM's overall regulatory role is to provide oversight of the long-term management of corrective and preventive actions by service providers once Queensland Health is satisfied the public health risk has been addressed.

Recycled water

The DERM administers the regulatory requirements for managing recycled water produced by recycled water providers for purposes such as golf course irrigation and industrial supply. The requirements for recycled water providers are detailed in the Water Supply Act and a series of regulatory guidelines.

During a flood event the majority of recycled water schemes have no need to supply water. However, in response to the January 2011 floods Queensland Health gave approval (with DERM endorsement) to recycled water providers for the Western Corridor Recycled Water Scheme for the use of purified recycled water and Class A+ recycled water for wash down purposes.

E. Adequacy of forecasts and early warning systems particularly as they related to the flooding events in Toowoomba, and the Lockyer and Brisbane Valleys

Stream Flow Gauging Station Network

As outlined in the State of Queensland's first submission dated 11 March 2011, DERM operates its stream flow gauging stations network for the primary purpose of water resource planning and management. In addition, DERM's gauging station information is used to support infrastructure planning in Queensland and to contribute to BOM's flood warning system.

Current Status of DERM's Stream flow Gauging Station Network

The DERM operates 389 stream flow gauging stations throughout the State and of these 372 are located in the flood or cyclone prone areas. The present situation in relation to the gauging station network is outlined below:

(a) 315 gauging stations are operational;
(b) 50 gauging stations have had preliminary repairs and are operating within acceptable limits with further restoration work yet to be carried out;
(c) 2 gauging stations were severely damaged by floodwater and require rebuild; and
(d) 5 gauging stations are currently classed as status unknown.

The 5 gauging stations with status unknown are detailed in the report, a copy of which is attached and marked '**DERM-04**'.

This is not of immediate concern for DERM's purposes given that data being collected by these stations is for long term planning. It is highly likely that these stations are continuing to log data for these requirements.

Of these, the Rudd Creek gauging station is functioning for and reporting to BOM. The Burdekin River at Blue Range gauging station is communicating intermittently but is a low priority for BOM. The communications issues at the Leichhardt River at Floraville, Oaky Creek at Texas and Culgoa River at Woolerbilla gauging stations are being addressed by DERM as a priority for BOM for the 2011-2012 wet season.

The 2 gauging stations that are non-operational are:

(a) 143306A Reedy Creek at Upstream of Byron Creek Junction; and

(b) 143307A Byron Creek at Causeway.

The Reedy Creek gauging station was completely destroyed by floodwater. The Byron Creek gauging station was inundated by floodwaters but suffered no structural damage. Both are in close proximity to each other within the Brisbane Basin on the Stanley River. Currently neither station is collecting data. These stations are not used by BOM for flood warning purposes.

BOM use of DERM Gauging Stations for Flood Warning

Some of the gauging stations within DERM's network are used by BOM for flood warning purposes. BOM accesses DERM's gauging station infrastructure under the following two scenarios:

(a) BOM uses DERM's existing gauging station infrastructure such as the gauging station hut to house BOM and or council owned flood warning instrumentation. In this scenario BOM typically attaches its instrumentation to DERM's instrumentation e.g. BOM installs a separate stream height transducer that runs in parallel with DERM's instruments, whilst both share a common gas-capillary line to the river. BOM typically uses its own separate telemetry systems to transmit data. DERM does not undertake maintenance of BOM owned instrumentation installed within DERM gauging stations; and

(b) The DERM has established a telemetry network which enables access to near-real time data from some of its gauging stations within the network; data from the telemetered sites is forwarded to BOM (approximately every 15 minutes) as the data comes into DERM's systems. BOM is also able to directly access DERM's

telemetry enabled gauging stations to download near-real time stream height data for flood warning purposes.

The DERM operates 258 gauging stations in Central West, South West and South East catchments and thirteen of these were affected by floodwaters during the 2010/11 Flood Events. BOM uses seven of these thirteen gauging stations for its flood warning system.

During the flood events, DERM regularly informed BOM of any known gauging station problems with the stations within the DERM network that BOM used for flood warning purposes. The DERM worked closely with BOM's staff to make repairs to gauging stations. This was only possible in situations where access could be safely gained to a gauging station site. The primary objective for DERM at that time was to ensure the operation of the gauging station network. During the flood event DERM undertook, as a matter of priority, repairs to 12 of its gauging stations at the request of BOM.

The DERM provided an update to the then Minister for Natural Resources, Mines and Energy and Minister for Trade via a Ministerial Briefing Note which was noted by the Minister on 5 January 2011 informing the Minister of the situation. A copy of the briefing note is attached and marked as '**DERM-05**'.

Minister Robertson was advised on 11 February 2011 (attached and marked as '**DERM-06**') that DERM had responded to nearly all requests received from BOM since September 2010 to repair critical gauging stations in south east Queensland.

On 23 February 2011 DERM wrote to BOM to provide an update on the status of DERM's gauging station network (attached and marked as '**DERM-07**').

The DERM is now working with BOM to upgrade 72 gauging sites across Queensland before the start of the 2011/12 wet season. The new technology uses satellite internet protocol communications to improve the reliability of available near-real time data.

Lockyer Valley Gauging Stations

BOM uses a gauging station on Lockyer Creek located at Helidon as a flood warning station. This station was operational during the flood events in the Lockyer Valley up until it was inundated by flood waters on 10 January 2011. Temporary repairs have been completed to this gauging station and the station is able to collect stream flow measurements. Further repairs will be carried out in the future.

The DERM operates one gauging station on Murphy's Creek in the Lockyer Valley. BOM does not use data from this gauging station for flood warning purposes. During the period leading up to the flooding in the Lockyer Valley the Murphy's Creek gauging station was collecting stream flow data however due to intermittent and weak mobile phone signal this data was not available in near-real time. The DERM is reviewing options to address communication service and reliability.

Two other gauging stations in the Lockyer Valley were seriously affected by the flood event. Seven gauging stations continue to operate with some infrastructure damage which is being assessed with respect to being able to deliver reliable information.

Data Collection and Processing

The data collected by DERM from the gauging station network is stored in DERM's Water Accounting System (WAS) Hydstra proprietary database. This data goes through a process of validation by hydrographic officers and is 'quality coded' to clearly identify the relative reliability of the data. This data is available free of charge and may be accessed either via DERM website or via formal request for a particular gauging station or stations.

The DERM has received many requests since the flood events from consultants, engineers and the general public to provide stream flow data from flood affected areas and has allocated additional resources for this activity. This data is being provided on a priority basis while still adhering to the quality assurance processes undertaken in DERM for data supply. Hydrographic officers are validating the relevant telemetry data from identified priority sites as a quickly as possible. The validation of all south east Queensland telemetry data and rating data has now been completed.

Rating Curves

The DERM's water monitoring framework is subject to a continual improvement process under DERM's quality management framework which is ISO 9001 endorsed.

In order to turn measured stream heights into flow velocities in cubic metres per second (cumecs), the height flow relationship is established under a prescribed methodology. This information is presented in what is known as a rating curve. A rating curve is developed by measuring the cross sectional area of the stream along with velocities (cumecs) at selected points throughout the full range of heights experienced at the site. This process is commonly referred to a stream flow measurement or gauging. Stream flow measurements are collected over a long period time and during various flow events. Therefore it can take many years to collect enough stream flow data to build a reliable rating curve.

To ensure that opportunities to undertake stream flow measurements are taken, DERM works in conjunction with BOM to place hydrographic officers at key locations where predicted significant stream flow events may take place. The DERM placed hydrographic officers in the field continuously from before Christmas Day 2010 to undertake measurements.

The DERM uses data collected from measuring stream flow to recalibrate rating curves. This process is undertaken following stream flow measurement to ensure that the relationship between stream height and flow at that particular gauging location is current.

For example, the Savages Crossing rating curve is considered reliable for river heights of up to 15.87 metres. During the 2011 flood, the actual river height peaked at 24.3 metres at this gauging station. This is 8.43 metres above the current calibrated stream height. Given that 15.87 metres was the historical peak prior to the 2011 flood event it was not possible to calibrate the rating curve for stream heights above this level and up to 24.3 metres. The rating curve was explicitly qualified as being a predictive tool for river heights above 15.87 metres. This means that any flow volumes derived from

the gauging station's rating curve above the calibrated stream height of 15.87 metres are 'quality coded' such that they are treated with caution.

F. Implementation of the systems operation plans for dams across the state and in particular the Wivenhoe and Somerset release strategy and an assessment of compliance with, and the suitability of the operational procedures relating to flood mitigation and dam safety

Dam safety

Chapter 4 of the Water Supply Act regulates 'referable dams' and 'flood mitigation manuals' in Queensland and is administered by DERM, as the dam safety regulator.

As the dam safety regulator, DERM produces the following:

(a) Guidelines on acceptable flood capacity for dams;
(b) Guidelines for failure impact assessment of dams;
(c) Queensland dam safety management guidelines; and
(d) Procedure for flood mitigation manual for a dam.

Guidelines on acceptable flood capacity for dams

These guidelines (a copy of which is attached and marked as '**DERM-08**') relate to the flood safety of water dams, and more specifically, to the selection of an Acceptable Flood Capacity (AFC) and adequate spillway provisions for all proposed and existing referable dams in Queensland.

These guidelines detail the:

(a) Available methods for determining the required flood discharge capacity for referable dams;
(b) Procedures to be followed when applying these methods;
(c) Reporting requirements when reporting the results of these investigations to the chief executive of DERM (the regulator); and
(d) Timeframe for any necessary dam safety upgrades.

Guidelines for failure impact assessment of water dams.

These guidelines (a copy of which is attached and marked as '**DERM-09**') have been developed to help owners comply with the Water Supply Act and dam safety conditions for referable dams (these include both conditions relating to dam safety imposed on development permits and safety conditions imposed under the Water Supply Act).

The Guidelines provide information about:

(a) Referable dams;
(b) Failure impact ratings;
(c) Failure impact assessment and how it is done;
(d) Certification of a failure impact assessment;
(e) Lodging a failure impact assessment for an existing dam;
(f) Lodging a failure impact assessment for a new or proposed dam;
(g) Lodging a failure impact assessment for works on an existing dam;
(h) Timing requirements for undertaking failure impact assessments;
(i) Processes for accepting, rejecting or reviewing a dam failure impact assessment; and
(j) Responsibilities, penalties and provisions for appeals.

Queensland dam safety management guidelines

The aim of the Queensland Dam Safety Management Guidelines for referable dams (a copy of which is attached and marked as '**DERM-10**') is to describe practices dealing with the construction and management of referable dams and assist dam owners to safely manage their dams and protect the community from dam failure.

It is to be used by:

(a) Owners of referable dams;
(b) Operators of referable dams;
(c) Employees of referable dam owners and operators; and
(d) Consultants for referable dam owners and operators.

These guidelines outline best practice used in Australian Standard for Quality Systems AS/NZS ISO 9001-3:1994 (Lam) [Quality Systems - Model for quality assurance in design, development, production, installation and servicing] in dam safety and are primarily advisory in nature. However, development permit conditions imposed on individual dams under the provisions of the *Water Act 2000* and the *Sustainable Planning Act 2009* (SPA) may "call up" or reference relevant sections of these guidelines as a way of undertaking particular activities (e.g. preparing an emergency action plan).

A dam safety management program should ultimately result in six levels of documentation being available for each dam. These are the:

(a) Investigation, Design, and Construction Documentation including Data Book, Design Report and As-Constructed Details (or Construction Report);
(b) Standing Operating Procedures (SOPs);
(c) Detailed Operating and Maintenance Manuals (DOMMs);
(d) Inspection and Evaluation Reports;
(e) Dam Safety Review Report 2; and
(f) Emergency Action Plan (EAP).

DS 5.1 Flood Mitigation Manual for a Dam

The DS 5.1 Flood Mitigation Manual for a Dam procedure (a copy of which is attached and marked as '**DERM-11**') provides a framework for assessing a flood mitigation manual for a dam required by the chief executive under Chapter 4, Part 2 of the Water Supply Act.

Section 370 of the Water Supply Act provides that dam owners may be required to prepare a flood mitigation manual. Section 371 of the Water Supply Act provides the chief executive with the power to approve, by gazette notice, a flood mitigation manual for a dam. Section 372 of the Water Supply Act provides that a flood mitigation manual may be subject to amendment by DERM and section 373 provides for review by the owner of a dam. Section 374 provides that the owner of a dam "does not incur civil liability for an act done, or omission made, honestly and without negligence in observing the procedures" in the manual.

Currently only three dams, being Wivenhoe, Somerset and North Pine dams owned by Seqwater, are required to prepare and have approved flood mitigation manuals. The primary reason for these dams to have flood mitigation manuals is that they are used for flood mitigation purposes and have gates where flow can be controlled.

Seqwater has its own internal system operation plans which do not require DERM approval. These plans are intended to ensure compliance with the flood mitigation manual. For example, Seqwater in its Flood Procedure Manual assigns responsibilities to Seqwater personnel for flood preparation, flood event mobilisation and flood event operations.

Manual of Operational Procedures for Flood Mitigation at Wivenhoe Dam and Somerset Dam – flood mitigation manual for Wivenhoe Dam and Somerset Dam

Section 2.9 of the flood mitigation manual for Wivenhoe Dam and Somerset Dam provides that:

"Seqwater must prepare a report for each Flood Event. The report must contain details of the procedures used, the reasons therefore and other pertinent information. Seqwater must forward the report to the Chief Executive within six weeks of the completion of the Flood Event."

Section 7.4 of the flood mitigation manual for Wivenhoe Dam and Somerset Dam provides that:

"After each significant flood event, Seqwater must report to the Chief Executive on the effectiveness of the operational procedures contained in this manual. This report must be submitted within six weeks of any flood event that requires mobilisation of the Flood Operations Centre."

In compliance with the above, Seqwater provided to the Director-General of DERM, a report entitled "January 2011 Flood Event Report on the operation of Somerset Dam and Wivenhoe Dam 2 March 2011" (Seqwater W & S report) on 2 March 2011. The

Seqwater W & S report was hand delivered to the Queensland Floods Commission of Inquiry on that same date. The Seqwater W & S report has now been made publicly available on the DERM website at: http://derm.qld.gov.au/commission/

The Seqwater W & S report addresses its compliance with the flood mitigation manual for Wivenhoe and Somerset dams and the scope for potential changes in dam operational arrangements related to flood mitigation.

The report includes Seqwater's assessment of the significance of the January 2011 Flood Event, Seqwater's operational response during the event and Seqwater's assessment of its compliance with the flood mitigation manual and the effectiveness of monitoring, modelling and communications systems.

The DERM is currently analysing the Seqwater report which includes considering:

(a) The process followed by Seqwater in relation to the times that key decision were made (e.g. opening flood gates more quickly to prevent triggering the fuse plugs);
(b) Whether it is necessary to vary the procedures in the flood mitigation manual in accordance with the experiences from the flood event;
(c) The effect of varying the Full Supply Level from its current Elevation Level (EL) of 67 metres;
(d) The performance of the Wivenhoe and Somerset Dams in the flood event;
(e) Seqwater W & S report recommendations; and
(f) Seqwater W & S report conclusions.

Manual of Operational Procedures for Flood Mitigation at North Pine Dam 11 March 2011 – flood mitigation manual for North Pine Dam

North Pine Dam is also required under the Water Supply Act to have a flood mitigation manual.

In compliance with the above, Seqwater provided to the Director-General of DERM a report entitled "January 2011 Flood Event Report on the operation of North Pine Dam 11 March 2011" (Seqwater North Pine report) on 11 March 2011. The Seqwater North Pine report was hand delivered to the Commissioner of the Queensland Floods

Commission of Inquiry (the Commissioner) on that same date.

The Seqwater North Pine report has now been made publicly available on the DERM website at: http://derm.qld.gov.au/commission/.

In a letter dated 20 March 2011, the Director-General of DERM wrote to Seqwater stating that the Seqwater North Pine report raises issues which need to be evaluated in relation to the ability of North Pine dam to manage rare flood events, noted that Seqwater was currently undertaking investigation actions and requested Seqwater's urgent advice on those investigation actions (particularly any urgent advice as to risk mitigation procedures). A copy of the letter is attached and marked as '**DERM-12**'.

The DERM is also conducting a similar analysis of the Seqwater North Pine report as detailed above in relation to the Seqwater W & S report.

Seqwater is required to provide reports under section 2.9 of the flood mitigation manuals after each flood event. Due to the number of flood events within the meaning of the flood mitigation manuals that occurred at Wivenhoe, Somerset and North Pine Dams in October 2010, December 2010, January 2011 and February 2011, the Chief Executive Officer of Seqwater wrote to the Director, Dam Safety of DERM by letter dated 24 February 2011 (a copy of which is attached and marked '**DERM-13**') requesting the following extensions of time for the following reports:

(a) 11 March 2011 for the January 2011 flood event report for North Pine Dam (now provided to DERM); and
(b) 31 May 2011 for the October 2010 and December 2010 flood event reports for Wivenhoe, Somerset and North Pine Dams and the February 2011 flood event report for North Pine Dam.

The Director-General of DERM wrote to the Chief Executive Officer, Seqwater by letter dated 8 March 2011 (a copy of which is attached and marked '**DERM-14**') approving those extensions.

Toowoomba Flood Event

Drainage lines in East Creek and West Creek Toowoomba contain ponds and detention basins of various sizes owned and operated by Toowoomba City Council. The purpose of a detention basin is for it to fill with flood water during an event and for that water to then drain out of the basin at a non-damaging rate. There are 28 detention basins and ponds along East Creek and West Creek in Toowoomba. While the basins are dams within the meaning of the Water Supply Act, none of the basins automatically trigger the requirement for a failure impact assessment under the Act.

The chief executive of DERM has the power under section 343(5) of the Water Supply Act to require the owner of a dam to undertake a failure impact assessment. This power can only be exercised when the chief executive reasonably believes there would be population at risk if the dam were to fail. In 2005, DERM conducted a preliminary assessment of the Alderley Street detention basins on West Creek. This assessment recommended that further investigation be conducted to determine the extent of the potential population at risk. After this assessment was undertaken, a detention basin was constructed in Long Street. Further, an assessment of coincident flow down East Creek was not included. Therefore, a further inspection was conducted in 2009 as part of the State-wide large farm dams project and the assessment was ongoing at the time of the flood event in Toowoomba.

The television footage of the flash flood which struck Toowoomba on 10 January 2011 indicated the presence of 'flood waves' which led the Dam Safety team in DERM to consider if those waves had been caused by a structural failure of the detention basins. Due to the flooding event in the Lockyer Valley it was not possible for DERM to conduct an inspection of East Creek and West Creek in Toowoomba until 18 January 2011. A copy of that inspection report is attached and marked as '**DERM-15**'.

The report concluded that:

(a) No embankments associated with the ponds and detention basins collapsed during the storm, thus eliminating the possibility that the flood was aggravated by the collapse of a built structure; and

(b) The behaviour of the flood was probably the result of the interaction of the storm conditions and the drainage system.

The DERM is currently re-assessing these detention basins to determine if a failure impact assessment is required to be undertaken under the Water Supply Act. If it is appropriate after taking into account the prescribed criteria under section 374(6) of the Water Supply Act, then a failure impact assessment will be required to be completed before the beginning of the 2011/12 wet season.

Farm Dam Incidents

During the flood events in December 2010 and January 2011 no referable dams failed. There were 22 farm dam incidents due to various causes. There were no injuries and minimal property damage caused due to these dam incidents. Attached and marked '**DERM-16**' is a spreadsheet detailing location of the dams, real property description, latitude, longitude, dam identification number, complainant, incident description, action officer and action taken (personal information has been redacted).

Previous Flood Reports under flood mitigation manuals

Attached are three (3) previous flood reports provided under the flood mitigation manuals: -

(a) Interim Report on Operation of Wivenhoe Dam during Floods (April – May 1989) by Water Resources Commission (a copy of which is attached and marked as '**DERM-17**');

(b) Report to South East Queensland Water Board on Flood Events of February and March 1999 at Somerset Dam, Wivenhoe Dam & North Pine Dam by State Water Projects (a copy of which is attached and marked as '**DERM-18**'); and

(c) Report on Flood Events at Wivenhoe, Somerset and North Pine Dams May 2009 to July 2009 by Seqwater (a copy of which is attached and marked as '**DERM-19**').

In respect of the Report to South East Queensland Water Board on Flood Events of February and March 1999 at Somerset Dam, Wivenhoe Dam & North Pine Dam - the recommendations for changes to the flood operations manuals at section 18 of the

report have been fully implemented.

The issues where Somerset Dam was rising above full supply level while no significant inflows into Wivenhoe Dam were occurring, as raised in part 9 on Flood Management Strategies in the Report on Flood Events at Wivenhoe, Somerset and North Pine Dams of May 2009 to July 2009, have been addressed in Strategy 1 of the flood mitigation manual.

G. All aspects of land use planning through local and regional planning systems to minimise infrastructure and property impacts from floods

The DERM's first submission of 11 March 2011 referred to and provided a copy of the draft Queensland Flood Risk Management Audit Report (Audit Report) which outlined that DERM predominately has a technical advisory role. This includes providing a technical advice in flood management and stormwater management. In accordance with this role, DERM undertakes the following:

(a) Publishing and maintaining the *Queensland Urban Drainage Manual* available on DERM's website at http://www.derm.qld.gov.au/water/regulation/drainagemanual.html;

(b) Providing technical advice to the Department of Community Safety in its administration of *State Planning Policy on mitigating the adverse impacts of flood, bushfire and landslide* (SPP 1/03) which is currently under review by that department; and

(c) Providing technical support for flood mitigation subsidy programs currently under the Australian Government Natural Disaster Resilience Program administered in Queensland by the Department of Community Safety.

Regulation of a watercourse, lake or spring

The DERM regulates prescribed activities that occur within watercourses, lakes and springs. The *Water Act 2000* defines the terms, "watercourse", "lake" and "spring". The DERM's regulatory role is to assess applications under the SPA, *Water Act 2000*, *Vegetation Management Act 1999* and associated planning instruments.

The fundamental principle underpinning the legislation and planning instruments is ecologically sustainable development. Sustainability is a primary consideration when a decision maker considers an application for the removal of vegetation or quarry material from a watercourse.

Interfering with the flow of water

Interfering with water in a watercourse, lake or spring is regulated under the *Water Act 2000*. Interference with the flow of water in a watercourse includes the construction of a dam or weir, or diverting the flow of a watercourse. When assessing an application to interfere with the flow of water in a watercourse, the decision maker must consider the criteria under section 210 of the *Water Act 2000.* This criteria includes:

(a) Any plans or declarations that may apply;
(b) Existing authorities to interfere with water;
(c) The effect on natural ecosystems, the physical integrity of a watercourse, lake or spring; and
(d) The public interest.

If an application to interfere with the flow is approved, a water licence under the *Water Act 2000* will be granted. Subsequently, an application for development approval under the SPA must be made and is assessed against the *Water Act 2000*. If the application is approved, a development permit will be granted.

Taking quarry material from a watercourse

The taking of quarry material from a watercourse requires a resource allocation under the *Water Act 2000*. When assessing an application for an allocation of quarry material from a watercourse under section 282 of the *Water Act 2000*, DERM considers the sustainability of the quantity of take of quarrying materials, e. g. ensuring the quantity of material removed does not exceed the average material transport rate (the rate at which material is replenished). If an application to take quarry material is approved, a Quarry Material Allocation Notice (QMAN) will be granted. Subsequently, application must be made for a development approval and, if

approved this will include conditions to manage the impacts of the take to ensure the integrity of the watercourse and onsite and downstream impacts are managed, including such impacts as downstream water quality.

Dealing with water related development

Works used to interfere with the flow of water, or for the removal of riverine quarry material from a watercourse, lake or spring, may require development approval under the SPA. The DERM is the assessment manager for applications relating to works to interfere with the flow, collating responses from concurrence agencies and deciding the application, unless another agency, such as a local government, is the assessment manager. For development applications relating to the removal of quarry material, DERM is the assessment manager unless a local government has made quarrying assessable development under their planning scheme (in these cases a local government would be the assessment manager and DERM would provide a concurrence response). If the proposal forms part of a larger development, for example a golf course that also involves construction of a dam on a watercourse, DERM may be a concurrence agency providing its response to the assessment manager (in this instance the relevant local government).

Riverine protection

Unless otherwise permitted, a riverine protection permit is required under the *Water Act 2000* to destroy vegetation, excavate or place fill in a watercourse. When assessing an application for a riverine protection permit, the decision maker assesses the application against the criteria under section 268 of the *Water Act 2000*, which includes whether destroying vegetation, excavating or placing fill in the watercourse will effect water quality, or result in erosion loss of habitat and ecological function within the watercourse. If an application is approved, a riverine protection permit is granted under the *Water Act 2000*.

Certain entities that include local governments and the State may undertake riverine protection activities without a permit if they operate under the "Guideline – Activities in a watercourse, lake or spring carried out by an entity". This allows such entities to destroy vegetation, excavate or place fill in a watercourse in order to control erosion

or carry out flood mitigation around public infrastructure such as road crossings.

The "Guideline – Activities in a watercourse, lake or spring carried out by an entity" is available on the DERM website at:
http://www.derm.qld.gov.au/about/policy/documents/4167/wap_2010_4165.pdf

River improvement trusts

The *River Improvement Trust Act 1940* provides for the establishment of river improvement trusts to undertake erosion protection and flood mitigation works in the areas for which they are established. For example, the Pioneer River Improvement Trust covers all watercourses in the Mirani and Mackay City local government areas and undertakes levee bank construction and erosion protection works using funding from council precepts. The DERM provides technical approvals for works proposals and provides a governance oversight role.

The Webbe-Weller review of government boards, committees and statutory authorities recommended that the functions of the State's 15 River Improvement Trusts be transferred to local governments. The DERM is working with River Improvement Trusts and affected local governments to implement the new institutional arrangements so transfers can be progressed by mid-2012.

Vegetation management

The *Vegetation Management Act 1999* and regional vegetation management codes regulate the clearing of native vegetation within and adjacent to watercourses, lakes and springs. These codes consider the effect of vegetation clearing on the bank stability, water quality, aquatic and terrestrial habitat of watercourses and wetlands. Clearing is restricted within buffer distances of watercourses, lakes, springs and wetlands. Buffer distances depend on the size of the watercourse, lake, spring or wetland. Clearing can be permitted within these buffers if the applicant can demonstrate that the clearing will not have an effect on bank stability (for watercourses), water quality, aquatic and terrestrial habitat. If an application is approved a development permit is issued under the SPA.

Technical advice on stormwater management

The *Queensland Urban Drainage Manual* is a guideline for engineers and designers planning and designing urban stormwater systems in Queensland.

The manual considers:

(a) Hydrologic and hydraulic procedures;

(b) Environmental and legal issues;

(c) Technical and regulatory aspects;

(d) Appropriate design methods; and

(e) Computational procedures.

State Planning Policy 1/03 - mitigating the impacts of flood, bushfire and landslide

SPP 1/03 requires the identification of natural hazard management areas within which minimising the risks to the community should be a key consideration in development assessment and the preparation of planning schemes. Until natural hazard management areas are identified in planning schemes, Annexure 3 of the SPP should be used for development assessment.

The Department of Community Safety assists with the application of the SPP where requested.

The DERM's role in supporting other agencies in the implementation and review of SPP 1/03 is to provide advice on landslide and floodplain management issues and the latest climate change science advances as well as storm tide and climate change issues.

The DERM's advisory role is triggered when a Regional Plan or a planning scheme is made under the SPA. Section 11.6 of the South East Queensland Regional Plan is an example of high level planning principles that must be reflected in local planning instruments and development assessments.

In the making of a planning scheme by a local government authority, DERM's role is to contribute to the whole of government state interest check including the State's interest in mitigating the impacts of flood, bushfire and landslide under SPP 1/03.

In the event that development is proposed below the identified flood level then the planning scheme will trigger assessment under the integrated development assessment system (IDAS) to ensure flood risk is adequately mitigated. This assessment is undertaken by the local government authority.

Local government authorities may develop a flood plain code for self assessment of development within the flood plain.

Technical advice on flood management

Assessing Flood Damage

Guidance on the assessment of tangible flood damages (a copy of which is attached and marked as '**DERM-20**') was published in September 2002, by DERM's predecessor, the Department of Natural Resources & Mines, to provide information to help applicants under the then Australian Government Regional Flood Mitigation Program (now replaced by the Natural Disaster Resilience Program) to assess tangible flood damages (i.e. damages that can be estimated in dollars). This guidance was provided as technical support to assist applicants and Emergency Management Queensland manage the assessment process.

The guideline focuses on estimating the value of potential physical damage that flood inundation may cause to property and infrastructure in an urban environment. It also explains the common methods and approaches used for estimating this damage, and converting the result to an average annual damage figure, which is necessary for calculating costs and benefits.

This guidance is consistent with broadly accepted methods, including those described in Report 73 of the SCARM Series, *Floodplain Management in Australia: Best*

Practice Principles and Guidelines (2000) (available from CSIRO Publishing).

Best Practice Principles

Floodplain management in Australia: best practice principles and guidelines (2000) (available from CSIRO Publishing) defines the context of floodplain management and includes guidelines to further develop the best practice principles. It also deals with practical issues to be considered as part of the floodplain management process.

The DERM has also undertaken an Inland Flooding Study Project which was referred to in the submission of 11 March 2011.

Coastal Management

Under the SPA, DERM may be either a referral agency or assessment manager for any of the following:

(a) If the land is located in a Coastal Management District (CMD) or seaward of a coastal building line - Material Change in Use, Reconfiguration of a Lot, Operational works, Building works; and
(b) Construction of a canal, prescribed tidal works or tidal works.

Tidal work activities include:

(a) Interfering with quarry material on State coastal land above high-water mark;
(b) Disposing of dredge spoil or other solid waste material in tidal water;
(c) Draining or allowing drainage or flow water or other matter across State coastal land above the high-water mark;
(d) Constructing or installing works in a watercourse where the works are not assessable under the Water Act 2000 or the Water Supply Act;
(e) Reclaiming land under tidal water;
(f) Constructing an artificial waterway;
(g) Constructing a bank or bund wall to establish a ponded pasture on land, other than State coastal land, above the high-water mark; and
(h) Removing or interfering with coastal dunes on land, other than State coastal land, that is an erosion prone area and above the high-water mark.

Protection of wetlands in Great Barrier Reef catchments

In May 2010, a wetland protection package was introduced to help protect wetlands of high ecological significance in Great Barrier Reef catchments from the effects of high impact earthworks. The package is considered necessary to stop the decline in reef water quality and the loss and degradation of wetlands that are not currently protected by other legislation.

The wetland protection package includes a Temporary State Planning Policy 1/10: Protecting Wetlands of High Ecological Significance in Great Barrier Catchments and amendments to the Sustainable Planning Regulation 2009. The changes establish wetland protection areas around significant wetlands in Great Barrier Reef catchments and create an assessment framework under the planning legislation for certain kinds of development in these wetland protection areas. The temporary State Planning Policy is valid for 12 months and expires on 2 May 2011.

The "Temporary State Planning Policy 1/10: Protecting Wetlands of High Ecological Significance in Great Barrier Catchments" is available on the DERM website at: http://www.derm.qld.gov.au/wildlife-ecosystems/ecosystems/pdf/wetlands-spp.pdf

New Draft State Planning Policy

In addition to this current protection package, DERM is considering making a final State planning policy to take effect when the temporary State Planning Policy expires. As part of this process, DERM released a Draft State Planning Policy: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments on 10 December 2010 for public consultation and submission.

The "Draft State Planning Policy: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments" is available on the DERM website at: http://www.derm.qld.gov.au/wildlife-ecosystems/ecosystems/pdf/draft-wetlands-spp.pdf

Referable Wetlands

Wetland protection areas are shown on a map of referable wetlands. These are the areas where DERM has a concurrence role in assessing applications for certain development involving large scale earthworks.

The map of referable wetlands can be viewed on the DERM website at:
http://www.derm.qld.gov.au/wildlife-ecosystems/ecosystems/referable-wetlands-maps.html

Sustainable planning

The list of developments that DERM has responsibility for as an advice agency, concurrence agency or assessment manager under the *Sustainable Planning Regulation 2009* is attached and marked as '**DERM-21**'.

The assessment codes are available on the DERM website at:
http://www.derm.qld.gov.au/water/management/assessmentcodes.html
http://www.derm.qld.gov.au/vegetation/regional_codes.html

Index of documents attached to

DERM

Exhibit	Description
DERM-01	Water quality advisory to all local governments prior to Christmas 2010
DERM-02	Spreadsheet showing information sought from councils re water and sewage
DERM-03	Situation Report dated 16 March 2011 regarding Joint Disaster Response/Recovery – 2010-11 Qld floods & Cyclones Anthony and Yasi
DERM-04	Report on Gauging Stations where status is unknown
DERM-05	Ministerial Briefing Note noted 5 January 2011 on the status of the state-wide network of gauging stations operated by DERM
DERM-06	Ministerial Briefing Note noted 11 February 2011 to Minister Robertson regarding Queensland gauging station update
DERM-07	Letter dated 23 February 2011 from DG of DERM to BoM regarding gauging station status
DERM-08	Guidelines on acceptable flood capacity for dams
DERM-09	Guidelines for failure impact assessment of water dams
DERM-10	Queensland dam safety management guidelines
DERM-11	DS 5.1 Flood Mitigation Manual for a Dam

DERM-12	Letter of 20 March 2011 from Director-General of DERM to Seqwater regarding North Pine Dam report issues
DERM-13	Letter dated 24 February 2011 from CEO of Seqwater to Director, Dam Safety of DERM requesting extension of time to provide flood event reports
DERM-14	Letter of 8 March 2011 from Director-General of DERM to CEO of Seqwater approving extensions of time
DERM-15	Inspection Report – Toowoomba – East and West Creeks
DERM-16	Farm Dam Failures Spreadsheet
DERM-17	Interim Report of June 1989 by Water Resources Commission on Operation of Wivenhoe Dam during Floods of April – May 1989
DERM-18	Report to South East Queensland Water Board on Flood Events of February and March 1999 at Somerset Dam, Wivenhoe Dam & North Pine Dam by State Water Projects on 14 September 1999
DERM-19	Report on Flood Events at Wivenhoe, Somerset and North Pine Dams May 2009 to July 2009 by Seqwater dated July 2009
DERM-20	Guidance on the assessment of tangible flood damages
DERM-21	DERM Development Assessment Checklist

'DERM-01'

Queensland Government

Department of
Environment and Resource Management

Advisory Information

Impact of recent weather conditions on managing drinking water supplies and advice for the Christmas closure period

The Office of the Water Supply Regulator (OWSR) has noticed an increase in *E.coli* incident notifications in recent times.

The pattern of these notifications is unusual in that the detections are occurring at a frequency and level that has not historically been associated with the particular drinking water supplies.

It is highly probably that the unseasonably high rainfall being experienced in Queensland is resulting in the increased level of *E.coli* detections.

This situation is further cause for concern due to the impending Christmas closure period, where service provider staffing and sample analysis capabilities are significantly reduced.

Consequently, over the Christmas period, the OWSR advises all drinking water service providers to ensure they have:

- Reviewed all operational procedures to ensure the ongoing effectiveness and efficiency of treatment processes during periods of high rainfall, increase turbidity and reduce staff availablility.
- Ensure incident and emergency procedures, plans and contacts are current.
- Ensure operational monitoring is continued throughout the Christmas period
- Make arrangements to ensure the continuation of *E.coli* sampling and analysis where possible
- Increase disinfection levels where appropriate

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CHRONOLOGICAL HISTORY OF 2010/2011 FLOOD EVENT - WATER SUPPLY AND SEWERAGE DAMAGE OUTSIDE OF SEQ

LOCAL GOVERNMENT	SERVICE	SCHEME NAME (SERVICED TOWNS)	STATUS 30/12/2010	STATUS 5/11/2011	STATUS 11/01/2011	STATUS 17/01/2011	STATUS 21/01/2011	STATUS 27/01/2011	STATUS 28/01/2011	STATUS 4/02/2011	STATUS 16/02/2011	STATUS 1/03/2011	STATUS 9/03/2011
Balonne Shire Council	Water Supply	Bolton		Not contacted.		No serious issues for Bolton	No issues			No issues	No issues		
		Dirranbandi (Bore Water)		Not contacted.	Water supply consists of a 25 percent blend of hot (65oC) bore and 75% treated river water for the remainder. If the treatment plant is flooded, the bore has sufficient capacity to supply the town.	The WTP is operating at normal production capacity.				No issues	No issues		
		Dirranbandi (River Water)		Not contacted.	There are sufficient chemicals for the surface water treatment plant to last 2 months.	The WTP is operating at normal production capacity.				No issues	No issues		
		Hebel		Not contacted.						No issues	No issues		
		Mungindi		Not contacted.						No issues	No issues		
		St George (Bore Water)		Not contacted.	No issue with potable reticulated bore water. Reticulated raw water supply for most toilets, AC's and fire fighting is threatened by sand ingress.	The bore water supply scheme (direct into reticulation) is producing normal supplies				No issues	No issues		
		St George (Surface Water)		Not contacted.	Reticulated raw water supply for most toilets, AC's and fire fighting is threatened by sand ingress.		The river water intake is damaged, a temporary diesel pump is providing supply			Operating under generous irrigation restriction (8 hrs/d Odds Evens). Temporary floating intake/pump. De-silting of reservoir underway. Upgrade needs to establish less vulnerable intake	The reservoir has been desilted. There is a persisting problem with sand build up over the intake and the volume of sand and difficulty with access means the problem may persist for some time The substituted float pump is operating successfully		
		Thallon		Not contacted.		No serious issues for Thallon	No issues			No issues	No issues		
	Sewerage	Bolon		Not contacted.			No issues			No issues	No issues		
		Dirranbandi		Not contacted.	No problems expected.	Dirranbandi sewerage scheme is operating normally	STP fully operational. All sewage pumping stations fully operational. No chemicals used in treatment process. No STP by-passing – discharge to wet weather storage within levee bank area.			No issues	No issues		
		St George		Not contacted.	No expected failure of any sewerage pump stations or sewerage treatment plant at flood levels previously experienced. Wet weather storage capacity for treated effluent may not be sufficient if flooding is prolonged.	No expected failure of any sewerage pump stations or sewerage treatment plant at flood levels previously experienced. Wet weather storage capacity for treated effluent may not be sufficient if flooding is prolonged	STP fully operational. All sewage pumping stations fully operational. No chemicals used in treatment process. No STP by-passing – discharge to wet weather storage. Previous comment that effluent capacity may not be sufficient if flooding is prolonged.			Fully operational. The wet weather storage is approaching full capacity due to a significant level of inflow/infiltration due to the flooding but they can quickly develop emergency bund if necessary	The inflow and infiltration has slowed down and is no longer an issue. The wet weather storages didn't overflow but are still very full even though reuse has started again and there are conditions conducive to evaporation again		
Shire ncil	Water Supply	Baralaba				Baralaba has not been affected.				No issue	No issue		
		Biloela/Thangool				Biloela has been previously affected but is now operating normally.	Lime is in short supply but expect to be able to source from their other plants until the order arrives.			No issue	No issue		
		Cracow								No issue	No issue		
		Goovigen				Goovigen has not been affected.				No issue	No issue		
		Moura/Banana				Moura and Banana have been previously affected but are now operating normally.				No issues now or longer term	No issues now or longer term		
		Taroom (Treated)				Taroom has been previously affected but is now operating normally.	Now operating			No issues now or longer term	No issues now or longer term		
		Taroom (Untreated)				Taroom has been previously affected but is now operating normally.				No issues now or longer term	No issues now or longer term		
		Theodore	Identification of parts of the system that are working. Ergon to restore power system on a progressive basis.	Identification of parts of the system that are working. Ergon to restore power system on a progressive basis. Army to provide temporary WTP. Existing WTP to be taken to Rockhampton for cleaning? 2-3 days work, 4-5 days to be back including transportation? Mains breaks to be fixed as well. Until water, sewerage and power are restored, people will not be allowed back, also the store must be operational.	Theodore issues are still evolving. Council have a water purification system at Theodore.	Theodore scheme is at normal production while under a boil water alert which is expected to be lifted today pending results from QH.	Scheme is at normal production. Boil water alert lifted at noon 19/1/2011			Normal potable production. No abnormal mains breaks now.	Normal potable production. No abnormal mains breaks now.		
		Wowan				Wowan has been previously affected but is now operating normally.				No issues now or longer term	No issues now or longer term		
	Sewerage	Biloela			Sewerage services have been restored.	Biloela has been previously affected but is now operating normally.	Were previously affected, now operating normally			No issues now or longer term	No issues now or longer term		
		Moura			Sewerage services have been restored.	Moura has been previously affected but is now operating normally.	Were previously affected, now operating normally			No issues now or longer term	No issues now or longer term		
		Theodore		Theodore - macerating plant inundated? Until water, sewerage and power are restored people will not be allowed back, also the store must be operational.	Sewerage services have been restored.	Theodore sewerage scheme is operating although treated effluent ponds are bypassed.	STP receiving normal flows and is being appropriately treated. All sewage pumping stations are fully operational. Effluent holding ponds are at capacity therefore treated effluent is discharging into the Dawson River which is in minor flood. No chlorination of effluent as the chlorination equipment is damaged.			No issues now or longer term	No issues now or longer term		
		Taroom			Sewerage services have been restored.	Taroom has been previously affected but is now operating normally.	Were previously affected, now operating normally			No issues now or longer term	No issues now or longer term		
Bundaberg Regional Council	Water Supply	Bundaberg		Temporary fixes working? Water intake damage - Ben Anderson Barrage for Bundaberg scheme??	1 x low level reservoir in Bundaberg (East Depot) has floated and cracked.	WTP at Branyan is not operational - all raw water is being sourced from the bore supplies, and meeting restricted demand, as the intake structure at Branyon WTP needs to be assessed for damage when water levels drop.	The WTP at Branyan is not operational due to the poor quality of the Burnett River water- water is being sourced from the bore supplies, and is meeting restricted demand. The intake structure at Branyon WTP – currently not being used - needs to be assessed for damage when water levels drop, otherwise no major issues. The scheme is still using the bore supply and will be until mid February due to the very high turbidity presently in the Burnett River. The cracked reservoir at the East Depot has been bypassed till repairs can be made. There was some concern with the supply of chlorine, as Council got down to only 4 days supply, however resupply has occurred and all facilities now have at least one months supply available.	The WTP at Branyan continues to remain offline until the turbidity levels in the Burnett river return to normal. The river continues too be in minor flood. The water supply is being sourced from the bore supplies, and is meeting demand and quality.		Branyon WTP intake appears to have sustained only minor damage, however a detailed assessment is to be done over the next few weeks. The plant will not be put back on line until June this year, not only because of the flood, but because this is an annual practice as the groundwater is the preferred raw water as it is much cheaper to treat and council has a generous allocation.	The only flood damage at the Branyan WTP inlet structure appears to be the fencing. This is being repaired at the moment as emergent work due to public/security access issues and is estimated to cost $5000.		
		Burnett Downs				Water supplies are okay, no major issues				No issues	No issues		
		Childers Woodgate				Water supplies are okay, no major issues	Fully operational. May have THM problems due to high turbidity/organics in the raw water reacting with a high chlorine dose. However Council is monitoring the situation			The Gregory WTP (supplies Childers, Woodgate, Red Ridge and Forest Ridge) has ongoing issues but not just because of the recent flood. Whenever turbidity and colour increase in the Gregory River the DAF process cannot treat the water to an acceptable standard. Planning is underway to construct a clarifier and pilot plant testing will soon be carried out to determine a suitable process.	The Gregory WTP (supplies Childers, Woodgate, Red Ridge and Forest Ridge) has ongoing issues but not just because of the recent flood. Whenever turbidity and colour increase in the Gregory River the DAF process cannot treat the water to an acceptable standard. Planning is underway to construct a clarifier and pilot plant testing will soon be carried out to determine a suitable process.		
		Gin Gin				Water supplies are okay, no major issues				No issues	No issues		
		Gooburrum				Water supplies are okay, no major issues				No issues	No issues		
		Kalkie				Water supplies are okay, no major issues				No issues	No issues		
		Lake Monduran				Water supplies are okay, no major issues				No issues	No issues		
		Moore Park				Water supplies are okay, no major issues				No issues	No issues		
		River Park				Water supplies are okay, no major issues				No issues	No issues		
		Sylvan Woods				Water supplies are okay, no major issues				No issues	No issues		
		Wallaville	No power to WTP but tanks are full and no issue for community.	No power to WTP but tanks are full and no issue for community.		Water supplies are okay, no major issues	Fully operational. May have THM problems due to high turbidity/organics in the raw water reacting with a high chlorine dose. However Council is monitoring the situation			Monitoring has proven that the THM concerns with the Wallaville WTP potable water are unfounded, no issues.	Monitoring has proven that the THM concerns with the Wallaville WTP potable water are unfounded, no issues.		
		Winfield (Rocky Point)				Water supplies are okay, no major issues				No issues	No issues		
	Sewerage	Coral Cove				Sewerage systems okay, no major issues				No issues	No issues		
		Lake Monduran				Sewerage systems okay, no major issues				No issues	No issues		
		Woodgate				Woodgate sewage treatment plant's wet weather effluent storage lagoon is overflowing to Theodolite Creek.	Wet weather effluent storage lagoon is overflowing to Theodolite Creek.			STP is operating normally and inlows are back to normal. No issues	STP is operating normally and inlows are back to normal. No issues		
		Childers				Sewerage systems okay, no major issues				No issues	No issues		
		Gin Gin				Sewerage systems okay, no major issues				No issues	No issues		
		Bargara			Damage has occurred to sewer mains. 2 sewer main ruptures at Bargara. 2 sewer trunk mains ruptured in Bunderberg, several rising mains exposed by scouring from flood waters. Relining equipment/ contractors are needed for collapsed sewers.	Sewerage systems okay, no major issues - a number of sewerage mains damaged, but Council is dealing with those ok, no major disruption to services.				There is currently no public health or environmental issues associated with the damage to sewer mains. There is sewer system CCTV and restoration work to be undertaken in the coming weeks.	Some sewer CCTV work and restoration works have been undertaken and will continue in the areas that were worst affected, they assume that there will be more repair work discovered over the coming weeks/months. Some problems have been caused by flood damage but others may be just a result of wear and tear.		
		Bundaberg	Inundated and pumping into Burnett River. Have technical expertise to get the system fully operational when water recedes.	Inundated and pumping into Burnett River. Have technical expertise to get the system fully operational when water recedes.	Damage has occurred to sewer mains. 2 sewer main ruptures at Bargara. 2 sewer trunk mains ruptured in Bunderberg, several rising mains exposed by scouring from flood waters. Relining equipment/ contractors are needed for collapsed sewers.	STPs are operational, however, Millbank STP is currently only treating to a primary standard due to high flows and the chlorination equipment is water damaged, expecting to go to secondary treatment later this afternoon. Bundaberg East STP is currently treating to secondary standard only due to high flows and the chlorination equipment is also water damaged.	Both Millbank and East Bundaberg STPs are operational and flood waters have receded from both sites. The Millbank plant was completely submerged except for the control building. It is producing a better effluent than East Bundaberg. There was water damage to the chlorination equipment at both of these plants but Millbank plant is now chlorinating and the East Bundaberg chlorination should be back on line by COB today. The current flow through East Bundaberg is 14.8 ML/d which is 200% ADWF. Millbank flows are still unknown as very little electronic equipment is functioning and flows are still very high, but no bypassing is occurring. Both plants discharge to the Burnett River which is in minor flood. Three minor sewage pump stations are still out of service but these only service sporting grounds which will not be in use for some time any way. A number of sewerage mains are damaged - but no major issues (overall sewer system is okay). Council is dealing with the damaged mains & there are no major disruptions to services.	Both the Millbank and East Bundaberg STP are now both in a position to chlorinate effluent and are still operating at flows slightly higher than normal. The Burnett River is still in minor flood. Three minor sewage pump stations are still out of service but these only service sporting grounds which will not be in use for some time any way. A number of sewerage mains are damaged - but no major issues (overall sewer system is okay). Council is dealing with the damaged mains & there are no major disruptions to services.		STP's are operating normally and inflows are back to normal. There is currently no public health or environmental issues associated with the damage to sewer mains. There is sewer system CCTV and restoration work to be undertaken in the coming weeks.	Some sewer CCTV work and restoration works have been undertaken and will continue in the areas that were worst affected, they assume that there will be more repair work discovered over the coming weeks/months. Some problems have been caused by flood damage but others may be just a result of wear and tear.		
	Water Supply	Anakie				Water supplies are okay, no major issues				No issues	No issues		
		Bauhinia Downs				Water supplies are okay, no major issues				No issues	No issues		
		Blackwater				Water supplies are okay, no major issues				No issues	No issues		
		Bluff		Bluff to be looked at on 5/1/2011, some temporary fixes. Main breaks Bluff?	WS pipeline from Blackwater to Bluff has a major break. Repair options are still being investigated.	Water supplies are okay, no major issues				No issues	No issues		
		Capella				WTPs are operational and producing normal volumes - Capella WTP is running low on chlorine, a resupply is waiting to leave Rockhampton and should arrive before the chlorine runs out				No issues	No issues		
		Comet				Water supplies are okay, no major issues				No issues	No issues		
		Dingo				Water supplies are okay, no major issues				No issues	No issues		
		Duaringa		Duaringa to be looked at on 5/1/2011, some temporary fixes. Main breaks Duaringa?		Water supplies are okay, no major issues				No issues	No issues		
		Emerald	No issues - Emerald WTP above water and still operating.	No issues - Emerald WTP above water and still operating.	Emerald WTP above water level.	Water supplies are okay, no major issues				No issues	No issues		
		Rolleston				Water supplies are okay, no major issues				No issues	No issues		

'DERM-02'

CHRONOLOGICAL HISTORY OF 2010/2011 FLOOD EVENT - WATER SUPPLY AND SEWERAGE DAMAGE OUTSIDE OF SEQ

LOCAL GOVERNMENT	SERVICE	SCHEME NAME (SERVICED TOWNS)	STATUS 30/12/2010	5/11/2011	11/01/2011	17/01/2011	21/01/2011	27/01/2011	28/01/2011	STATUS 4/02/2011	STATUS 16/02/2011	STATUS 1/03/2011	STATUS 8/03/2011
Central Highlands Regional Council		Sapphire-Rubyvale				Water supplies are okay, no major issues				No issues	No issues		
		Springsure				Water supplies are okay, no major issues				No issues	No issues		
		Tieri				Water supplies are okay, no major issues				No issues	No issues		
		Willows Gemfields				Water supplies are okay, no major issues				No issues	No issues		
	Sewerage	Springsure				STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress				No issues	Council have recently found out that 2 sewerage pump stations in Rolleston have developed problems and can only be run on manual until electrical repairs can be made	Council have engaged contractors to carry out the repair works and they should be fully operational within a few weeks	Purchase orders have been issued to contractors to carry out repairs, these are currently underway with parts on order. Reinstatement of full automatic services is dependent on availability and delivery of parts.
		Rolleston				STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress							
		Blackwater				STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress				No issues	No issues		
		Emerald	Several pump stations out of operation. Emerald STP to be inspected today. Partial operation.	Several pump stations out of operation, no issues with Emerald STP.		STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress, some pump stations are still being pumped out in readiness to be put back on line.				One pump station remains offline due to damage to the electrics, awaiting replacement parts	One sewerage pump station in Emerald is operating with the soft starter bypassed while Council waits for the new parts to be installed	Council have engaged contractors to carry out the repair works and they should be fully operational within a few weeks	Purchase orders have been issued to contractors to carry out repairs, these are currently underway with parts on order. Reinstatement of full automatic services is dependent on availability and delivery of parts.
		Capella				STPs are operational. Sewerage systems okay, no major Issues - Council is happy with progress				No issues	No issues		
		Tieri				STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress				No issues	No issues		
		Bluff				STPs are operational. Sewerage systems okay, no major issues - Council is happy with progress				No issues	No issues		
Cherbourg Aboriginal Council	Water Supply	Cherbourg			No known issues	Situation has not changed from yesterday. Cherbourg lost power on Tuesday of this week and power was restored to the community on Wednesday but not to the water supply intake pumps and the WTP. Two diesel generators have been brought in Wednesday and were connected to the intake pumps and the WTP by late Wednesday afternoon. The water supply is now operational and producing sufficient water supplies. Normal operation is expected by later today. Restrictions are in place to manage demand. Had a main break down to the farm which has now been shutdown, so town system should be back to normal by early afternoon. Ergon have advised that they need to install a couple of poles and run new lines which should be completed over the weekend. Road access between Cherbourg and Murgon has been restored this morning.	The water supply is now operational and producing sufficient water supplies. Mains power was restored over the weekend 15/16 January. Floating intake approx 30 metres up a tree, raw water supply OK through opening at intake structure. Restrictions are in place to manage demand. Water supply is currently operating satisfactorily without its control system being fully available.	Local plumbers have been on-site and may have to manufacture a special device to reinstate the floating intake. Some mention has been raised about making a pontoon and the cost of $20,000 was mentioned. Water supply is currently operating satisfactorily without its control system being fully available. Restrictions are in place to manage demand.		Water supply is still being maintained through the intake structure following emergency temporary repairs to make one pump operational, ie. manual control only. The plumbers are currently working off-site to manufacture a suitable device to reinstate floating intake. Damage to creek pumps was extensive with the pump shed completely submerged, ie pumps, main switchboard and soft starters completely inoperable. A temporary switchboard and soft starter have been installed on a power pole above flood level. The second pump has a short circuit in the motor and is inoperable. The plumbers are also arranging that an emergency back-up pump and necessary equipment is available for an electrical connection for this pump.	Pump has been installed on floating pontoon and connected directly to pipeline to WTP. Now bypassing the Intake Structure. LGIS are preparing a report to evaluate options to refurbish or to replace the Intake Structure	Pump has been installed on floating pontoon and connected directly to pipeline to WTP. Now bypassing the Intake Structure. LGIS are preparing a report to evaluate options to refurbish or to replace the Intake Structure.	
	Sewerage	Cherbourg			No known issues	STP is operational. Some problems with pump stations which are being addressed.	STP is operational following inundation of the lagoons. Plant is passing normal ADWF into the creek which is running at normal flows. Sewage pump stations are operational. Unsure regarding chemicals?	One wet-well sewage pump station is still out of action down at the farm area which was completely flooded, with major damage to electrics, etc. Only three occupied houses draining to this wet-well, so a pump out truck visits on a regular basis (ie. every 3 to 4 days).		PS 4 inoperable at this stage. Pumping-out still continuing but only three occupied houses drain to this wet-well. Station was completely submerged with the switchboard broken form its mounts, tipped over and the case broken. The switchboard has been removed from site for workshop repairs. The broken switchboard casing has been repaired and new control equipment ordered, expected to be delivered in early February. PS 1 sustained minimal damage and is fully operational. PS No.2 was completely submerged and requires a full rebuild of switchboard and control equipment. One pump is operational and the second pump is faulty with a short circuit in the motor. Emergency repairs make it operational once power restored. Further repairs to switchboard and replacement of faulty pump is necessary to make station fully operational. PS 3 was completely submerged and requires a full rebuild of switchboard and control equipment. One pump operational and second pump running but not pumping. Further repairs to switchboard and possible replacement of faulty pump is necessary to make station fully operational. LGIS & Aurecon had a	PS 4 still offline and pump out facilities still in place. PS 1 was not flooded, minor damage and is operational. PS 2 & 3 did go under in the flood and are operational but still require major electrics to be replaced	PS 4 still offline and pump out facilities still in place. PS 1 was not flooded, minor damage and is operational. PS 2 & 3 did go under in the flood and are operational but still require major electrics to be replaced	
Fraser Coast Regional Council (Wide Bay Water Corporation)	Water Supply	Maryborough					No issues			No issues	No issues		
		Eli Creek					No issues			No issues	No issues		
		Pulgul					No issues			No issues	No issues		
		Toogoom					No issues			No issues	No issues		
		Burrum Heads					No issues			No issues	No issues		
		Hervey Bay					No issues			No issues	No issues		
		Torbanlea					No issues			No issues	No issues		
		Nikenbah								No issues	No issues		
		Tiaro								No issues	No issues		
		Wide Bay								No issues	No issues		
		Howard											
	Sewerage	Maryborough				Three sewage pump stations in the Maryborough sewage treatment plant catchment remain off line. Wide Bay Water envisages these stations will be back on line by COB Friday 14 January 2011.	STP operational. 3 pump stations in the Maryborough sewage treatment plant catchment remain off line. Wide Bay Water envisages these stations will be back on line by COB Friday 14 January 2011.			Back to normal and all pump stations are operational and have been for some time	Back to normal and all pump stations are operational and have been for some time		
		Hervey Bay (includes Eli Creek, Pulgul, Toogoom, Burrum Heads, Torbanlea and Howard)				STP operating as normal.	Eli Creek and Pulgul Creek STPs are currently releasing treated effluent to the respective receiving waters, 24 hours a day, outside of license conditions. Normally these plants irrigate 90% of treated effluent.			Back to normal. Eli Ck and Pulgul Ck STP discharging to irrigation lands. As the ground is still very saturated and low lying, the STP's at Toogoom and Burrum Heads still have infiltration issues likely to be resulting in loadings 20 to 30% above ADWF	The Toogoom & Burrum Heads schemes are back to normal following a couple weeks of relatively dry weather. Issues with the Toogoom scheme in particular have been resolved by Council improving the stormwater drainage system where manholes had been underwater and infiltration occurred. Apparently, the SES personnel had created inflow into the sewer system by lifting manhole covers to drain private property in several locations. Some sewer lines and manholes became blocked with debris entering the sewerage system. The SES believed they had the power and authority to do this, but did not realise the ramifications of their actions. Council need to sort this issue out with SES prior to future events and apparently the manhole covers have now been bolted down to prevent unauthorised lifting	As previously advised for 16/2/2011. Toogoom and Burrum Heads are operating as normal for this time of the year.	
		Nikenbah				STP operating as normal.	No issues			No issues	No issues		
Goondiwindi Regional Council	Water Supply	Bungunya				currently not experiencing problems.	No issues reported			No issues	No issues		
		Goondiwindi				Water supplies are okay, no major issues and Goondiwindi should operate normally as long as the town levee prevents flooding of the town.	No issues reported			No issues	No issues		
		Inglewood				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Talwood				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Texas				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Toobeah (Bore Water)				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Toobeah (Surface Water)				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Yelarbon											
	Sewerage	Goondiwindi				Sewerage systems are okay, no major issues and Goondiwindi should operate normally as long as the town levee prevents flooding of the town.	No issues reported			No issues	No issues		
		Inglewood				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Talwood				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Texas				Currently not experiencing problems.	No issues reported			No issues	No issues		
		Yelarbon											
Gympie Regional Council	Water Supply	Amamoor			WTP flood bound and thus filters cannot be backwashed, however there is at least 2 days supply in the reservoirs.	WTPs are operational and producing normal volumes				Council is planning to install automatic backwash systems to all the small Mary Valley WTP's in the future, so the issue of not being able to get an operator into backwash the filters because of flooding will be overcome.	Council is planning to install automatic backwash systems to all the small Mary Valley WTP's in the future, so the issue of not being able to get an operator into backwash the filters because of flooding will be overcome.		
		Goomeri			WTP is OK. Did lose a few bores.	WTPs are operational and producing normal volumes				No issues	No issues		
		Gympie			WTP - Jones Hill WTP is at least 6 metres above the current river level. Water for WTPs is sourced from Yabba, Kandanga and Amamoor Creeks.	WTPs are operational and producing normal volumes	WTP operational and producing normal volumes. As part of a contingency plan all WTP chemicals are topped up at this time of year, so there was no issue with supply(all roads to Gympie are now open). The only chemical shortage experienced was getting fluoride to commission the fluoride dosing equipment but this chemical was delivered yesterday.			No issues	No issues		
		Imbil			WTP is OK. Did lose a few bores.	WTPs are operational and producing normal volumes				Council is planning to install automatic backwash systems to all the small Mary Valley WTP's in the future, so the issue of not being able to get an operator into backwash the filters because of flooding will be overcome.	Council is planning to install automatic backwash systems to all the small Mary Valley WTP's in the future, so the issue of not being able to get an operator into backwash the filters because of flooding will be overcome.		
		Kandanga			WTP flood bound and thus filters cannot be backwashed, however there is at least 2 days supply in the reservoirs.	WTPs are operational and producing normal volumes				Two bores offline with two operating which are easily meeting demand, offstream storage full. Council also has another backup bore at the Bowls Club that can be used. Council has submitted an insurance claim for the pump sheds that were washed away so are awaiting insurance assessment before being repaired.	Indications are that the 2 bores that are off line were not needed at this time anyway and were mainly only used as a backup. The 2 operating bores are coping with demand easily and they also have a full off stream storage they can use if needed. Council is not in any hurry to get the 2 bores online and is waiting for the outcome of an insurance claim to replace the pump sheds. Council's pre and post flood contingency plan seems to be working very efficiently	The bores have been repaired and are operational and they have put in a claim for the repairs	
		Kilkivan			WTP is OK. Did lose a few bores.	Water supplies are okay, no major issues - lost one bore at Kilkivan but the other 2 are functioning ok	WTP is operational and producing normal volumes. Lost one bore at Kilkivan but the other 2 are functioning ok.						
		Rainbow Beach			WTP OK at present.	WTPs are operational and producing normal volumes				No issues	No issues		
		Tin Can Bay/Cooloola Cove			WTP OK at present.	WTPs are operational and producing normal volumes				No issues	No issues		
		Imbil			STP OK.								

CHRONOLOGICAL HISTORY OF 2010/2011 FLOOD EVENT - WATER SUPPLY AND SEWERAGE DAMAGE OUTSIDE OF SEQ

LOCAL GOVERNMENT	SERVICE	SCHEME NAME (SERVICED TOWNS)	STATUS 30/12/2010	STATUS 5/11/2011	STATUS 11/01/2011	STATUS 17/01/2011	STATUS 21/01/2011	STATUS 27/01/2011	STATUS 28/01/2011	STATUS 4/02/2011	STATUS 16/02/2011	STATUS 1/03/2011	STATUS 9/03/2011
Maranoa Regional Council	Sewerage	Gympie			GRC are having overflows and will have more. Power has been turned off to ten pump stations and they are anticipating that they will need to cut power to the rest. They are trying to save electrical equipment at present.GRC stated that sewage will go into the Mary river and water will fill up the whole system. The current STP is close to expected water levels but the new STP currently under construction is higher. The lagoons down the back of the plant are likely to go under.	STPs are operational. Sewerage systems okay, no major issues - some pump stations are still flood bound, but switchboards are being reinstalled as flood waters recede.	STP operational; currently handling 200% ADWF (4ML/day) with effluent discharging into the Mary river which is just below minor flood levels. As part of a contingency plan all STP chemicals are topped up at this time of year. There was no issue with supply as all roads to Gympie are now open.			No issues	No issues		
		Goomeri			STP OK.					No issues	No issues		
		Kilkivan			STP OK.		STP operational; As part of a contingency plan all STP chemicals are topped up at this time of year. There was no issue with supply as all roads to Gympie are now open.			After further damage assessment at the Kilkivan STP, it was found that a great deal of silting up has occurred in one of the lagoons due to it being covered by flood waters, however it has not created any effluent quality issues and will be de-silted over the coming weeks.	After further damage assessment at the Kilkivan STP, it was found that a great deal of silting up has occurred in one of the lagoons due to it being covered by flood waters, however it has not created any effluent quality issues and will be de-silted over the coming weeks.		
		Cooloola Cove			STP OK at present.					No issues	No issues		
		Rainbow Beach			STP OK at present.					No issues	No issues		
		Tin Can Bay			STP OK at present.					No issues	No issues		
	Water Supply	Amby		None		No serious issues reported.	No serious issues reported			No issues	No issues		
		Injune		None		No serious issues reported.	No serious issues reported			No issues	No issues		
		Jackson		None		No serious issues reported.	No serious issues reported			No issues	No issues		
		Mitchell		None	No serious issues reported.	No serious issues reported.	No serious issues reported			No issues	No issues		
		Muckadilla		None		No serious issues reported.				No issues	No issues		
		Mungallala		None		No serious issues reported.	No serious issues reported			No issues	No issues		
		Roma		None	No serious issues reported.	No serious issues reported.	No major issues reported			No issues - normal production (raw water supply restored)	No issues - normal production (raw water supply restored)		
		Surat (Treated)		None	Treated water supply is believed to be operating.	Water supply for Surat is ok but are expecting another flood peak about 19 January.	Water supply is okay (the information is for Surat in general, no mention wether it's a treated or untreated water supply)			No issues - normal production (raw water supply restored)	No issues - normal production (raw water supply restored)		
		Surat (Untreated)		None		Water supply for Surat is ok but are expecting another flood peak about 19 January.	Water supply is okay (the information is for Surat in general, no mention wether it's a treated or untreated water supply)			No issues	No issues		
		Wallumbilla		None		No serious issues reported.	No serious issues reported			No issues	No issues		
		Yuleba		None		No serious issues reported.	No serious issues reported			No issues	No issues		
	Sewerage	Mitchell		None	No serious issues reported.	No serious issues reported.	No major issues reported			No issues	No issues		
		Mungallala		None		No serious issues reported.	No major issues reported			No issues	No issues		
		Injune		None		No serious issues reported.	No major issues reported			No issues	No issues		
		Roma		None	No serious issues reported.	No serious issues reported.	No major issues reported			No issues	No issues		
		Surat		None	Some inundation of sewerage reticulation and treatment ponds but believed to be operating.	Sewerage for Surat is ok but are expecting another flood peak about 19 January.	No major issues reported						
North Burnett Regional Council	Water Supply	Biggenden			Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems	WTP operating on manual as there are some telemetry problems. Sufficient chemical quantities available to operate to March.			No issues. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Eidsvold			Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems	WTP operating on manual as there are some telemetry problems. Sufficient chemical quantities available to operate to March.			Chlorination system and filtration system will require significant work as system is currently being nursed on manual operation. Water quality issues are requiring large chlorine doses with very little affect. Turbidity is high which is unusual as raw water is drawn from sand beds - (maybe sand beds have scoured away during the flood?) Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Gayndah	Partial supply re-established at 5pm today. Level 5 restrictions apply. Will know tomorrow if outside help is needed. DDMG offered assistance today. 2-3 days supply.	Gayndah WTP ok but infrastructure damage. LGIS to assist. Main breaks - Gayndah and Mundubbera? Partial supply re-established at 5pm today. Level 5 restrictions apply. Will know tomorrow if outside help is needed. DDMG offered assistance today. 2-3 days supply.	Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems	WTP operating on manual as there are some telemetry problems. Sufficient chemical quantities available to operate to March. There are concerns regarding possible damage to the river intake.	Temporary supply pumping arrangement still operating OK. Intake works are still under water and still no idea as to the extent of structural damage sustained.		Temporary pumping arrangement still in place. Still too dangerous to investigate extent of damage to intake. The watercourse has cut a new channel behind the intake structure which is isolated (now on a small island). At least two bore pumps missing. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	No progress since previous report apart from waiting on a report from Hunter Water to provide a long term option. Funding uncertainty is a big worry for Council and may dictate what can be affordable. Still have hired pumps as temporary arrangement	No progress since previous report apart from waiting on a report from Hunter Water to provide a long term option. Funding uncertainty is a big worry for Council and may dictate what can be affordable. Still have hired pumps as temporary arrangement	No progress since previous report. Report from Hunter Water to provide a long term option sshould be available by 31/3/2011.
		Monto			Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems	WTP operating on manual as there are some telemetry problems. Sufficient chemical quantities available to operate to March.			No issues. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Mount Perry			Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems				No issues. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Mulgildie			Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems				No issues. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Mundubbera	Supply will be supplemented tomorrow. Breaking into main and will use agricultural pump on a tractor to pump supply. Will know tomorrow if outside help is needed. DDMG offered assistance today. 1 day of supply.	Supply will be supplemented tomorrow. Breaking into main and will use agricultural pump on a tractor to pump supply. Will know tomorrow if outside help is needed. DDMG offered assistance today. 1 day of supply. Main breaks - Mundubbera?	Council advised that although some structural damage has occurred to the water supply infrastructure (i.e. intake structures), water supply to residents in all townships is being maintained.	All WTP's are operating on manual as there are some telemetry problems	WTP operating on manual as there are some telemetry problems. Sufficient chemical quantities available to operate to March. There are concerns regarding possible damage to the river intake.	Temporary supply pumping arrangement still operating OK, however work is currently underway to repair and get their bore pump operational so as not to be totally reliant on the temporary pump. Damage not expected to be excessive and anticipate getting bore pump operational		The bore pump has been made operational again on automatic control, however, system still very fragile with temporary repairs, should further flooding occurs. (ie. temporary pump is available on standby, if required). Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	As previously advised and would be at risk if river levels were to significantly rise again.	As previously advised and would be at risk if river levels were to significantly rise again.	
	Sewerage	Biggenden			Sewerage treatment plants apart from some minor damage and access issues are still functioning.	All STP's are operating OK, some Pump Stations are operating manually.	STP operating OK. Plant handling normal ADWF with discharges into normal river flows.Sewage pump stations are operational			No issues	No issues		
		Eldsvold			Sewerage treatment plants apart from some minor damage and access issues are still functioning.	All STP's are operating OK, some Pump Stations are operating manually.	STP operating OK. Plant handling normal ADWF with discharges into normal river flows.Sewage pump stations are operational but one is on manual control due to telemetry problems			Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Telemetry issues still have not been sorted, although Contractor had arrived on-site briefly for a specific purpose and had to leave		
		Gayndah	STP underwater. Pumping out wells now. Should be operational Friday morning, 31/12. DDMG offered assistance today.	Gayndah STP - pumping issues? STP underwater. Pumping out wells now. Should be operational Friday morning, 31/12. DDMG offered assistance today.	Sewerage treatment plants apart from some minor damage and access issues are still functioning.	All STP's are operating OK, some Pump Stations are operating manually.	STP operating OK. Plant handling normal ADWF with discharges into very high river flows.Sewage pump stations are operational			No issues	P/S was temporarily on auto but has failed again and now running on manual.	Telemetry issues are still unresolved	Telemetry issues are still unresolved. Repairs are weeks away and manual operation is not a signifcant issue.
		Monto			Sewerage treatment plants apart from some minor damage and access issues are still functioning.	All STP's are operating OK, some Pump Stations are operating manually.	STP operating OK. Recycled water scheme destroyed. Plant handling normal ADWF with discharges into normal river flows. Sewage pump stations are operational			Recycled water scheme destroyed and will eventually be replaced after more urgent priorities have been attended to.	No change		
		Mundubbera	STP underwater. Pumping out wells now. Should be operational Friday morning, 31/12. DDMG offered assistance today.	STP underwater. Pumping out wells now. Should be operational Friday morning, 31/12. DDMG offered assistance today.	Sewerage treatment plants apart from some minor damage and access issues are still functioning.	All STP's are operating OK, some Pump Stations are operating manually.	STP operating OK but was inundated. Plant handling normal ADWF with discharges into very high river flows. Sewage pump stations are operational but two are on manual control due to flood damage			No issues. Council waiting for their Telemetry contractor to visit Shire to fully check out and re-establish their control system. Some telemetry services have been restored at some installations.	Scheme still has manual control on two PS's	Telemetry issues are still unresolved	Telemetry issues are still unresolved. Repairs are weeks away and manual operation is not a signifcant issue.
Rockhampton Regional Council	Water Supply	Bajool (Community Scheme)	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply	n/a - not a council run water supply		
		Capricorn Coast				Flood waters have dropped 700 mm and flood level now @ 8.5 metres No issues at WTPs, all operating normally to all water supply schemes.	No issues at WTPs, all operating normally to all water supply schemes.			No issues	No issues		
		Marlborough				Flood waters have dropped 700 mm and flood level now @ 8.5 metres No issues at WTPs, all operating normally to all water supply schemes.	No issues at WTPs, all operating normally to all water supply schemes.			No issues	No issues		
		Mount Morgan				Flood waters have dropped 700 mm and flood level now @ 8.5 metres No issues at WTPs, all operating normally to all water supply schemes.	No issues at WTPs, all operating normally to all water supply schemes.			No issues	No issues		
		Ogmore				Flood waters have dropped 700 mm and flood level now @ 8.5 metres No issues at WTPs, all operating normally to all water supply schemes.	No issues at WTPs, all operating normally to all water supply schemes.			No issues	No issues		
		Rockhampton	No issues - Rockhampton WTP 11m above predicted flood level of 9.2m.	Email from RRC that they will not know extent of damage/problems until water recedes. Gracemere underwater. Rockhampton WTP at 12m is above predicted flood level of 9.2m.		Flood waters have dropped 700 mm and flood level now @ 8.5 metres No issues at WTPs, all operating normally to all water supply schemes.	No issues at WTPs, all operating normally to all water supply schemes.			No issues	No issues		
	Sewerage	Yeppoon					STP not affected by flood events.			No issues	No issues		
		Emu Park					STP not affected by flood events.			No issues	No issues		
		Gracemere	Gracemere STP underwater now, switchboard removed. No other problems anticipated for Rockhampton RC - all other plants above predicted flood level.	Gracemere STP underwater, switchboard removed. No other problems anticipated for Rockhampton RCC - all other plants above predicted flood level.	Sewerage treatment plants are still operating and functioning OK, however access to all STP's is only available via boat.	STP's are all functioning and operating OK, however still have access issues.	STPs are all operational. Switchboard & electrical gear was removed prior to flood event and is being reinstalled 19/1/2011. The clarifier was not inundated, but close to it. Back to ADWF ie. 1ML/day. Normally, discharges to lagoons and then to land, large lagoon was not flooded, however the smaller lagoons were and have now been pumped out. The larger lagoon is now able to discharge into the smaller lagoons. Sufficient quantities of chemicals on hand, but arrangements have been made to transport some supplies from North Qld due to problems of supplies coming out of Brisbane			Gracemere STP operating OK only the small lagoons were flooded and system is back to normal	Gracemere STP operating OK only the small lagoons were flooded and system is back to normal		

CHRONOLOGICAL HISTORY OF 2010/2011 FLOOD EVENT - WATER SUPPLY AND SEWERAGE DAMAGE OUTSIDE OF SEQ

LOCAL GOVERNMENT	SERVICE	SCHEME NAME (SERVICED TOWNS)	STATUS 30/12/2010	5/11/2011	11/01/2011	17/01/2011	21/01/2011	27/01/2011	28/01/2011	STATUS 4/02/2011	STATUS 16/02/2011	STATUS 1/03/2011	STATUS 9/03/2011
South Burnett Regional Council	Sewerage	Rockhampton		Email from RRC that they will not know extent of damage/problems until water recedes.	Sewerage treatment plants are still operating and functioning OK, however access to all STP's is only available via boat.	STP's are all functioning and operating OK, however still have access issues.	**North** Rockhampton STP is OK, not inundated, but was isolated. Handling < 2 ML/day, approx 30% above ADWF. Should be close to being back to normal in a day or two. All sewage pumping stations are OK and operational, however, there's some minor pump blockage - 3 other pumps are still available. **South** Rockhampton STP is OK; not inundated but was isolated. Handling approx 20-30% above ADWF, but this is dropping quickly. All sewage pumping stations are OK and operational. **West** Rockhampton STP is OK, partial inundation and was isolated. Plant is located on a high spot and even though the trickling filter was OK the clarifier was inundated. Handling very high flows approx 1200% ADWF but now is back to around 120% ADWF. All sewage pumping stations are OK and operational. North Rockhampton, South and West Rockhampton STPs all discharge into the Fitzroy River which is described as flowing at normal wet weather flows. Sufficient quantities of chemicals are on hand, but arrangements have been made to transport some supplies from up North due to problems with supplies coming out of Brisbane.	North Rockhampton STP is OK and is handling approx 20% above ADWF. South Rockhampton STP is OK and handling normal ADWF. It sustained some internal pipework which collapsed between clarifiers is currently being repaired. West Rockhampton STP is OK, and is handling approx 20% above ADWF. It is suggested that domestic and industrial cleaning up operations may still be impacting on flows to these STP but general inflow/infiltration through damaged sewers/manholes may also be a factor?		North Rockhampton still about 20% above ADWF but currently about 80% over with recent wet weather from Cyclone Yasi over the past 3 days. Suspect infiltration, etc with older mains along the coast and Council are proposing smoke detection program in the near future. This will not only pick-up illegal connections but will detect smoke coming from the ground (video camera monitoring, etc) Future maintenance issues will resolve. South Rockhampton still about normal as at 31/1 but currently about 50% over with recent wet weather from Cyclone Yasi over the past 3 days. Internal pipe collapse has been assessed but has not been repaired yet. This pipe (ie. not critical) is being bypassed but will need to be operational to allow maintenance activities to proceed. West Rockhampton still about 20% above ADWF but currently about 80% over with recent wet weather from Cyclone Yasi over the past 3 days. Similar comments as per North Rockhampton.	North Rockhampton and West Rockhampton plants are still experiencing flows 20% to 30% above ADWF flows. Recent rain storms mean the ground is still saturated. Infiltration is not believed to be flood related. Relining programs in these older areas have located some serious pipe damage and those pipes are currently being upgraded	North Rockhampton and West Rockhampton plants are still experiencing infiltration impacts that are not believed to be flood related. Relining programs in these older areas have located some serious pipe damage and those pipes are currently being upgraded	
		Mount Morgan					STP now operating at ADWF (80kL/day). Not affected by floodwaters.The only issue during the storms was a sewage pumping station was potentially compromised and bank stabilisation was necessary to protect this installation. - now OK.			No issues	No issues		
	Water Supply	Blackbutt/Benarkin			No known significant damage.	Operating normally.	No issues reported. Sufficient chemical quantities available			No issues	No issues		
		Kingaroy			No known significant damage.	Operating normally.	No issues reported. Sufficient chemical quantities available			No issues	No issues		
		Kumbia			No known significant damage.	Operating normally.				No issues	No issues		
		Lake Boondooma			No known significant damage.	Operating normally.				No issues	No issues		
		Murgon			Murgon water supply intake structure may be under threat from floodwaters.	Operating normally.	Water supply still on temporary supply (ie. Temporary Pump) this will be the case for some months until Intake PS is restored. The pumps & electrics sustained extensive damage. Sufficient chemical quantities available.			Intake pump motors destroyed, still operating under temporary pumping arrangement. Council are still investigating their options, they may make their temporary arrangement, ie. bores, a permanent solution. Investigating feasibility of submersible pumps, etc. Not sure at this stage what will be adopted.	No further progress to report regarding the intake.	No further progress to report. They are still considering their options for the longer term solution (ie. flood proof from future events) but will be dependent upon available funding to achieve this. Maintaining a record of costs for temporary pumping arrangements and if replacing original installation costs will be around $100K, however, this is the cheap option which would not be flood proofed. Obtaining quotes, prices, etc. while waiting for confirmation of funding.	
		Nanango			No known significant damage.	Operating normally.	No issues reported. Sufficient chemical quantities available.			No issues	No issues		
		Proston			No known significant damage.	Operating normally.	No issues reported. Sufficient chemical quantities available.			No issues	No issues		
		Tingoora (extension of Wondai WS)			No known significant damage.	Operating normally.				No issues	No issues		
		Wondai			No known significant damage.	Operating normally.	Water supply was initially damaged during flood event, but pumps OK and system back to normal. Sufficient chemical quantities available.			No issues	No issues		
		Woorooilin			No known significant damage.	Operating normally.				No issues	No issues		
	Sewerage	Nanango			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP is operating OK after being inundated for 3-4 days. Plant handling normal ADWF with discharges into normal river flows. All sewage pumping stations operational			Final lagoon was flooded now OK	Final lagoon was flooded now OK		
		Kingaroy			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP is operating OK. Plant handling normal ADWF with discharges into normal river flows. One lagoon was flooded. All sewage pumping stations operational			Final lagoon was flooded now OK	Final lagoon was flooded now OK		
		Murgon			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP is operating OK. Plant handling normal ADWF with discharges into normal river flows. All sewage pumping stations operational			No issues	No issues		
		Blackbutt			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP is operating OK. Plant handling normal ADWF with discharges into normal river flows. No sewage pump stations - it has a gravity system.			No issues	No issues		
		Wondai			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP is operating OK. Plant handling normal ADWF with discharges into normal river flows. All sewage pumping stations operational			No issues	No issues		
		Proston			No known significant damage, apart from flooding issues at STP's and a suspected sewer main collapse.	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).	STP operating OK. Plant handling normal ADWF into lagoon.			Normal operation although significant distribution leak that cannot be isolated at present	A mystery leak persists in the reticulation following the flood - a known leak on the bridge crossing was fixed shortly after the flood abated		
Southern Downs Regional Council	Water Supply	Stanthorpe				Operating normally.	WTP operating normally; boil water alert lifted			Normal operation (although some electrical problems requiring a lot of operator attendance)	Electrical problems have been fixed		
		Wallangarra				Operating normally.	Boil water alert in place.			Operating under BWA but confident of clearance with QH result 5 Feb	BWA has been lifted after 3 good tests		
		Pratten				Operating normally.	Boil water alert in place.			No issues	No issues		
		Killarney				Operating normally.	No issues reported.			No issues	No issues		
		Leslie Dam				Operating normally.	No issues reported.			No issues	No issues		
		Warwick				Operating normally.	No issues reported.			No issues	No issues		
		Dalveen				Operating normally.	No issues reported.			No issues	No issues		
		Rosenthal Heights				Operating normally.	No issues reported.			No issues	No issues		
	Sewerage	Stanthorpe				Operating normally.	STP treating all sewage satisfactorily. All sewage pumping stations operational. High levels of inflow/infiltration and a full recycling storage requires discharge (chlorinated) of all treated effluent to Quart Pot Ck (3ML/d discharge to 170 ML/d flow in creek). No chemical supply problems.			Treating all sewage satisfactorily. Most works complete although some equipment still to be repaired. No longer-term repair issues. Discharging all treated effluent (<1ML/d to Quart Pot Ck 60 ML/d baseflow) due to no recycled water needs by farmers and a damaged cross-stream pipeline to the sporting fields/parks/gardens. Expect discharge for at least a couple of weeks at least pending farmer demand resuming	Recycling is now operating normally		
		Wallangarra				Operating normally.	No issues reported.			No issues	No issues		
		Killarney				Operating normally.	No issues reported.			No issues	There was some minor damage to the CED scheme that was a result of erosion - yet to be fixed	Washouts to the CED system have ben rectified	
		Leslie Dam				Operating normally.				No issues	No issues		
		Warwick				Operating normally.	No issues reported.			No issues except for 1 PS facility operating with temporary PS. Expect repair within a couple of weeks. This PS, 1 of 17, was flood damaged. Pumps in Brisbane for repair were caught in floods)	and also on the Yan pipeline.	Pump stations are back to normal. However, there are a number of washouts on pipelines around Warwick that have been identified	
		Dalveen				Operating normally.	No issues reported.			No issues	No issues		
		Rosenthal Heights				Operating normally.	No issues reported.			No issues	No issues		
Toowoomba Regional Council	Water Supply	Cambooya					No serious issues reported for any water supply schemes			No issues	No issues		
		Clifton					No serious issues reported for any water supply schemes			No issues	No issues		
		Greenmount					No serious issues reported for any water supply schemes			No issues	No issues		
		Hodgson Vale					No serious issues reported for any water supply schemes			No issues	No issues		
		Haden					No serious issues reported for any water supply schemes			No issues	No issues		
		Nobby					No serious issues reported for any water supply schemes			No issues	No issues		
		Toowoomba					No serious issues reported for any water supply schemes			No issues	No issues		
		Cecil Plains					No serious issues reported for any water supply schemes			No issues	No issues		
		Millmerran					No serious issues reported for any water supply schemes			No issues	No issues		
		Goombungee					No serious issues reported for any water supply schemes			No issues	No issues		
		Kingsthorpe					No serious issues reported for any water supply schemes			No issues	No issues		
		Yarraman					No serious issues reported for any water supply schemes			No issues	No issues		
		Wyreema					No serious issues reported for any water supply schemes			No issues	No issues		
		Highfields					No serious issues reported for any water supply schemes			No issues	No issues		
		Crows Nest					No serious issues reported for any water supply schemes			No issues	No issues		
		Hampton					No serious issues reported for any water supply schemes			No issues	No issues		
		Pittsworth/Brookstead					No serious issues reported for any water supply schemes			No issues	No issues		
		Blue Mountain Heights					No serious issues reported for any water supply schemes			No issues	No issues		
		Oakey/Jondaryan					No serious issues reported for any water supply schemes			No issues	No issues		
		Vale View					No serious issues reported for any water supply schemes			No issues	No issues		
		Perseverance Lodge					No serious issues reported for any water supply schemes			No issues	No issues		
		Cressbrook Dam								No issues	No issues		
	Sewerage	Clifton				Wetalla STP no longer bypassing. Missing section of 300mm sewer found downstream in Gowrie Creek. Council is recovering it and preparing to replace it with repairs at Griffiths St. Pumps operating as temporary repair to missing sewer main at North St.	Wetalla STP no longer bypassing. All sewage pumping stations operational. North Street- 300 Main across Gowrie Creek. Pumps in place and pumping to trunk sewer on west side of Gowrie Ck. /Standby pump in place. Sewage flow to creek has stopped. No reported overflows at peak flow. Griffith Street- 300 Main across Gowrie Creek now operational. Below Hospital 150 aerial main across Gowrie Creek - Has been repaired. A second 150 main which services only the tennis courts has been damaged. Repairs have been scheduled. East Street main break at 48 East St fixed. Main break at 32 East St , repairs still in progress, completion date uncertain due to difficulties with soil stability and terrain. Third main failure probably exacbated by third land slip (under investigation). A rising main break between SPS 28 and 29 East Street - repairs completed.	Wetalla STP no longer bypassing, normal treatment has resumed. All sewage pumping stations operational.		No long term issues. Bridge access to Wetalla STP damaged preventing tankered sewage discharge direct to STP. This is being discharged at an upstream manhole.	Wetalla has access back for trucks to get chemicals in and biosolids out		
		Toowoomba					No issues			No issues	No issues		
		Cambooya CED					STPs operating normally. All sewage pumping stations operational			No issues	No issues		
		Yarraman											
		Millmerran					STPs operating normally. All sewage pumping stations operational			No issues	No issues		
		Pittsworth					STPs operating normally. All sewage pumping stations operational			No issues	No issues		
		Wyreema				Loves Road (Wyreema) STP operational – with no bypass	Loves Road STP operational						
		Oakey				Oakey STP still has no power and the town has only one SPS operational. But council has found there is no break in sewer mains. Priority for council is to establish coarse screening and to restore operation of trickling filters.	STP performance severely compromised. All sewage pumping stations operational; Council progressively re-establishing treatment plant processes	Limited treatment currently being provided at normal ADWF, ie coarse screening, primary sedimentation, 1 x biofilter and chlorination – second biofilter due back online next week. Secondary sedimentation tanks will take weeks to re-establish (flooded for a second time week 17/21 January. All sewage pumping stations operational		All sewage primary screened and forced through 1 x Biofilter (small) and 1 x secondary sedimemtation tank. However daily peak flows bypass the biofilter and are chlorinated and discharged to the creek.The 2nd biofilter, the larger one, will hopefully be restored within 2 weeks. Access problems for trucks are hampering sedimentation tank recovery. Council is considering long term options for this plant.	Only some components are working - hope to have all elements of the treatment train operating by the end of month. The flow paced chlorinator got written off and is not to be replaced since it is proposed to transfer sewerage to Toowoomba	Some components still not operational - secondary sedimentation tank is not working and they are still manually dosing chlorine. The dosing is likely to remain that way until pumping to Toowoomba is instaled.	Currently providing secondary treatment at normal flow volumes. Council is preparing to pump sewage to the Wetalla STP at Toowoomba and this is programmed to be operation by the end of 2011.

CHRONOLOGICAL HISTORY OF 2010/2011 FLOOD EVENT - WATER SUPPLY AND SEWERAGE DAMAGE OUTSIDE OF SEQ

LOCAL GOVERNMENT	SERVICE	SCHEME NAME (SERVICED TOWNS)	STATUS 30/12/2010	STATUS 5/1/2011	STATUS 11/01/2011	STATUS 17/01/2011	STATUS 21/01/2011	STATUS 27/01/2011	STATUS 28/01/2011	STATUS 4/02/2011	STATUS 16/02/2011	STATUS 1/03/2011	STATUS 9/03/2011
Western Downs Regional Council	Water Supply	Kingsthorpe								No Issues	No Issues		
		Crows Nest				Highfields and Crows Nest – STP and SPSs are operational with no bypass.	STP operating normally. All sewage pumping stations operational			No Issues	No Issues		
		Cecil Plains					STP operating normally. All sewage pumping stations operational. Possible power issues to a number of the sewage pumping stations – backup generator sourced			No Issues	No Issues		
		Westbrook				Westbrook pump station N was overflowing yesterday and council has since engaged tanker contractor to recommence pump outs.	STPs operating normally. All sewage pumping stations operational			No Issues	No Issues		
		Highfields				Highfields and Crows Nest – STP and SPSs are operational with no bypass.	STP operating normally. All sewage pumping stations operational – there was some surcharging during recent storm events			No Issues	No Issues		
		Bell				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Brigalow				No serious issues are reported.	No issues reported.			Returned to normal operation. Main breaks have steadied up. Are operating from the Charlies Creek source, as there are electrical problems with Chinchilla Well PS.	Still issues with the raw water pumps and will be for a while	Still issues with the raw water pumps and will be for a while	
		Chinchilla	Believed to be a couple of serious breaks in the mains. Water and sewerage plants are above water and OK. Search and repair or isolate. 2-3 days supply expected at capacity.	Believed to be a couple of serious breaks in the mains. Water & sewerage plants are above water and OK. Search and repair or isolate. 2-3 days supply expected at capacity.	Despite serious flooding in Chinchilla the water and sewerage schemes are expected to function sufficiently in most areas.	Chinchilla WTP is operating at normal capacity	WTP is operating at normal capacity. Boiled water alert has been lifted. No chemical issues						
		Condamine	Mandatory evacuation underway. Small treatment plant. Water treatment plant & power will be off.	Mandatory evacuation. Assessment may take place today. Small treatment plant. Water treatment plant and power will be off.	Condamine water supply infrastructure is facing inundation again as the river levels rise fast and force evacuation.	Condamine is still totally evacuated. The WTP will be inundated again.	WTP now operational. No chemical issues	WTP now operational but has suffered significant damage. Is trealing adequate supplies but is operating under a precautionary boiled water alert. The ADF could not get their plant to operate properly as it would not produce anything better than 1.6NTU		WTP operational problems as result of inundation, hence BWA. but confident of clearance next week. Using temporary raw water pumps and gradually replacing damaged equipment. Priority will be for replacement of high lift pumps ($40k) and in longer term replacement of the raw water pump station	BWA is yet to be formally lifted - but tha tests have been done and are OK. High lift pumps will be replaced in a couple of weeks. Raw water pumps are still to be addressed - still temporary pump operating.	BWA lifted approx 1 week ago	
		Dalby	Will do assessment tomorrow. 5 days expected supply.	2nd RO plant operaitonal 5/1/2011. 4 of 13 bores operational?? Trucking in water to build up available storage, help from Toowomba Regional Council. Should be ok by end of week.	Dalby water supply is expected to resist any renewed flooding threats and maintain adequate supplies.	Dalby WTP is inoperable due to Condamine River flood ingress into clear water storage at the WTP. There is currently 2-3 days supply in service reservoir storage. Commenced carting 0.5-0.7 ML day from Toowoomba. Predicted time for the flood to recede below the clearwater storage is Sunday 16 Jan and the WTP should be operating within 24 hrs of that. The WTP should be able to return to limited production capacity (2.5-3 ML/d, 200-300 Lpd). WTP should be operating at 60% of capacity by late today, treated water is still being tankered from Toowoomba, level 6 restrictions still apply.	WTP is operational and producing 3.6ML/day. Level 5 restrictions still apply. No chemical issues.			Producing 4ML/d under Level 5 restrictions(although ther are political pressures to lift this restriction) with conventional WTP and 1 x RO plant drawing form 6 bores from the total of 15. Expecting 2nd RO plant on-line next week. Refurbishment expenditure about $1M over next 3 months mainly on RO plants and bores. Full recovery could take up to 12 mths	Second RO plant is on line as of today. Minor repairs still proceeding but plant is OK		
		Drillham				?				No Issues	No Issues		
		Dulacca				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Flinton				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Glenmorgan				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Jandowae			Jandowae is reported to be experiencing a record flood but Council is not aware of any serious effects on the water and sewerage schemes.	Previously affected water schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK.							
		Jimbour				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Kaimkillenbun				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Kogan				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Meandarra				Previously affected water schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK.	No issues reported.				No Issues		
		Miles	Water OK.	Water OK.		Previously affected water schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK.	No issues reported.			No Issues			
		Moonie				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Tara				Previously affected water schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK.	No issues reported.						
		The Gums				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Wandoan				No serious issues are reported.	No issues reported.			No Issues	No Issues		
		Warra	Very small community - most evacuated out. Alternative water being investigated. May need generator assistance to pump.	Very small community - most evacuated out. Alternative water being investigated. May need generator assistance to pump.	Warra WTP continues to be inoperable due to flood damage. With the Jandowae flood moving through and the Condamine R flooding, this situation is likely to persist. Drinking water is being tankered from Dalby.	Warra WTP continues to be inoperable due to flood damage and access problem. Drinking water is being tankered from Chinchilla	Warra WTP continues to be inoperable due to flood damage and access problem. Drinking water is being tankered from Chinchilla	Warra WTP should be returned to operation by 28/1/2011. Until that time drinking water is being tankered from Chinchilla	Warra WTP is now operational and operating under a boiled water alert until such time as the water quality can be verified.	WTP operating OK - however a BWA due to a small positive Ecoli test result and low Cl residual in the reticulation. Retesting to confirm if actual contamination or error.	Quality tests are OK and the BWA is soon to be removed	BWA lifted.	
		Westmar				No serious issues are reported.	No issues reported.			No Issues	No Issues		
	Sewerage	Chinchilla	Water and sewerage plants are above water and OK.	Water and sewerage plants are above water and OK.	Despite serious flooding in Chinchilla the water and sewerage schemes are expected to function sufficiently in most areas.	Chinchilla sewerage scheme is functioning OK although sub-optimal treatment.	STP operating OK. Plant handling normal ADWF flows. No chemical issues			No Issues	No Issues		
		Dalby			The sewerage collection system continues to function while most sewage is being bypassed at the treatment plant.	Dalby sewerage system is functioning without bypass.	STP operating OK. Plant handling normal ADWF flows. BNR section will not be back to normal until week commencing 24 January. All sewage pumping stations operational. No chemical issues			Primary/secondary treatment satisfactory. BNR process working but sub-optimally. (process stability issues)	Back to normal and supplying recycled water		
		Miles	Sewerage in trouble, further report tomorrow.	Sewerage in trouble, further report tomorrow.		Previously affected sewerage schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK	No issues reported			Normal operation - however extreme Inflow/Infiltration issue has not been resolved - this will be subject of longer term investigation (possible stormwater-to-sewer cross-connection?)	Back to normal. Minor issues in the treatment plant		
		Meandarra			Flooding may inundate the sewerage scheme again. However last time the scheme continued to operate.	Previously affected sewerage schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK	No issues reported.			No Issues	No Issues		
		Tara				Previously affected sewerage schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK	STP operating OK. Plant handling normal ADWF flows.			No Issues	No Issues		
		Wandoan					STP operating OK. Plant handling normal ADWF flows.			Normal operation - however some damage to oxidation lagoons (undermined pond liners) - to be repaired over next couple of months	No change		
		Jandowae			Jandowae is reported to be experiencing a record flood but Council is not aware of any serious effects on the water and sewerage schemes.	Previously affected sewerage schemes at Jandowae, Meandarra, Miles and Tara water are currently operating OK				No Issues	No issues		
		Condamine - private septic tanks (no STP)	Flooded septic tanks needing pumping when water subsides. May need septic pumpers?	Mandatory evacuation. Assessment may take place today. Flooded septic tanks needing pumping when water subsides. May need septic pumpers?			Inundated for a second time, septic scheme inoperative			Septic tanks were pumped out when the town reoccupied	Septic tanks were pumped out when the town reoccupied		
Woorabinda Aboriginal Council	Water Supply	Woorabinda	Power was out for 1.5 days. Water & sewerage lost when power is out. Significant number of renal patients requiring clean water. If pumps are flooded at Booralbia, town will lose water. 2 days supply when at capacity.	Power was out for 1.5 days. Water and sewerage lost when power is out. Significant number of renal patients requiring clean water. If pumps are flooded at Baralaba, town will lose water. 2 days when at capacity. Break in pipeline from weir/pump failure of some description? Rockhampton RC providing assistance? Cannot access Dawson River supply (pipeline from Neville Hewitt Weir) until water recedes? Council's water treatment consultant is stranded in town and is assisting? 1 of 3 bores in town is operational, water being tankered to holding ponds from Mimosa Creek, normally 2 bores are required to meet demand. Access to Mimosa Creek is deteriorating due to rainfall. The 3 (Blackboy 1, 3 and 4) bores are all very deep, approx. 1000m, and require specialist crews to deal with the pumps. Borefield is currently inaccessible and assessment of the problems are not possible - helicopter access maybe? Bore 1 - lineshaft driven helical rotor pump at 133m Bore 3 - submersible pump at 500m Bore 4 - ?? Neville Hewitt Weir - 2 submersible pumps in a pump well in the weir.	Bore 4 still operating OK at reduced capacity, normally 2 bores are required to meet demand. Water carting from Mimosa Creek has been able to be reduced to only one water tanker, access to the WTP has been improved with the construction of a temporary water main, such that the trucks now only use the bitumen pavement. The reservoir maintaining steady levels and currently @ 93% storage capacity (ie. 2 ML storage). The pump station wet-well intake at the Baralaba Weir has been inspected, however the duty pump is suspected to be blocked. There is still too much water in this vicinity to complete investigations. Council attempted to try and run the pump to check out condition of the rising main but were unable to start the pump. Pump 2 was in standby mode when station shutdown and should be OK once the site can be re-established. Council have contacted SunWater and are hoping to get this installation operational early next week - black soil conditions are even unsuitable for 4WD access and they will try access with a Quad vehicle next week, if needed. Electricia	Bore 4 still operating OK at reduced capacity, normally 2 bores are required to meet demand. Break in the water main where it passes under the Dawson River. A proposal is to lay a temporary main over the bridge to restore supply, however funding is still being organised as a contractor is available but needs a Job No. before commencing. Still too much water to check pump station. No chemical supply issues	Bore 4 still operating OK at reduced capacity, normally 2 bores are required to meet demand. Break in the water main where it passes under the Dawson River. A proposal is to lay a temporary main over the bridge to restore supply, however funding is still being organised as a contractor is available but needs a Job No. before commencing. Still too much water to check pump station. No chemical supply issues	Temporary water main over the bridge was not necessary, a section of main was uncovered but had not suffered a break. Council is preparing to start a pump, but have discovered yet another section of the pipeline that is uncovered and are working to cover this section, before pressurising the rising main. the staus of the pump station remains questionable until an attempt is made to start a pump. No chemical supply issues	Supply from Neville Hewitt Weir re-established. Water carting from Mimosa Creek has ceased. One pump supplying 15 L/sec, second pump has a problem (restricted to 5 L/sec) wet-well has rocks/debris which needs to be cleaned out before gaining access to check 2nd pump. Water level still too high to work safely in vicinity of wet-well. Temporary reinstatement around pipework supplying wet-well, will require permanent restoration and stabilisation of the supply main. Gravity main from break-pressure tank to WTP has had several washouts where some joints may have moved slightly near undermined & exposed concrete anchorage blocks. Council are still proposing to install a temporary pump @ Mimosa Creek and connecting the pipeline into the supply main to the WTP	No change to previous report, water level still too high to work safely in vicinity of wet-well. One pump operating OK, standby pump still off-line and out of service. Temporary pump installed at Mimosa Creek and is on standby, when required (ie. contingency plan). Permanent reinstatement of cover protecting the rising and gravity main sections of the supply main from the Dawson River still awaiting funding issues to be resolved. Contractor is available and can commence restoration within two weeks once funds secured. The temporary pumping installation at Mimosa Creek will be used to provide supply when contractor commences restoration works on the rising main from the Dawson River.	Supply main across the Dawson River was lost again following heavy rainfall in the catchment last Tuesday week, hence the Weir pump is now offline. River flows are currently overtopping the weir. Town water supply is currently from Mimosa Creek back-up pump arrengement and the Airport Bore. Council are currently relaying approx 40 metres of pipe across the Dawson River which will be encased in concrete to restore supply from the weir pumps. Council hope to complete this work before the weekend. They are concerned more wet weather flows are approaching with recent rainfall of 160mm at Taroom which flows into the Dawson River and takes a couple of days to reach the weir vicinity. The subsequent rises in river flows have impacted on the repairs to date. Council have been patching up several sections of washouts along the pipeline where approx. 600 metres requires attention. They have attempted to flush the wet-well but high river flows have prevented access.	Council completed the relaying of the suction main across the Dawson River on the 20 February (Sunday). Township is back on the Dawson River supply still with only one pump available. Mimosa Creek back-up pump is available, if required. Council have not progressed washout restorations along the pipeline until confirmation that the Government will fund these works. They have tried to flush out the wet-well, but debris still blocking No. 2 pump. No further efforts made to clear at this stage.	
	Sewerage	Woorabinda	Power was out for 1.5 days. Water & sewerage lost when power is out. STP is OK at the moment. Enough chemicals to see out the road closures (end of next week). Need enough generator capacity - if power is lost. May need pre-deployment of system? Monitoring - council plumber and electrician in town. Sewage flows straight through system - no holding capacity - overflow in a day at most.	Woorabinda sewerage is OK as there is no flooding in town. Power went out for 1.5 days. Water and sewerage lost when power is out. STP is OK at the moment. Enough chemicals to see out the road closures (end of next week). Need enough generator capacity - if power is lost. May need pre-deployment of system? Monitoring - council plumber and electrician in town. Sewage flows straight through system - no holding capacity - overflow in a day at most.	STP is operational, sewerage system okay, no issues.	STP is operational and delivering normal ADWF to land disposal. Sewage pumping stations operational. No chemical supply issues	STP is operational and delivering normal ADWF to land disposal. Sewage pumping stations operational. No chemical supply issues			No Issues	No Issues		

Flood affected water services outside south east Queensland										
Local Govt	**Town**	**Flood affected Town/s**	**Water Supply Scheme**	**Connected Population**	**Status of Water supply**	**Comments**	**Status of Sewerage System**	**Comments**	**Status of Solid waste Disposal**	**Comments**
Balonne Shire Council	St George	St George	St George drinking water supply scheme		The bore water supply scheme (direct into reticulation) is producing normal supplies		no expected failure of any sewerage pump stations or sewerage treatment plant at flood levels previously experienced	Wet weather storage capacity for treated effluent may not be sufficient if flooding is prolonged	No problems reported	
	Dirranbandi	Dirranbandi	Dirranbandi water supply scheme		WTP is operating at normal capacity.		sewerage scheme is operating normally		No problems reported	
	Bollon	Bollon			No serious issues		NA		No problems reported	
	Thallon	Thallon			No serious issues		NA		No problems reported	
Banana Shire Council	Theodore	Theodore	Theodore		Scheme is at normal production	Under a boil water alert which is expected to be lifted today pending results from QH	sewerage scheme is operating	treated effluent ponds are being bypassed.		Waste management services for Banana Shire council are normal
	Taroom	Taroom	Taroom		Now operating normally.	Was previously affected	Now operating normally.	Was previously affected		
	Moura	Moura	Moura		Now operating normally.	Was previously affected	Now operating normally.	Was previously affected		
	Wowan	Wowan	Wowan		Now operating normally.	Was previously affected	Now operating normally.	Was previously affected		
	Biloela	Biloela	Biloela		Now operating normally.	Was previously affected	Now operating normally.	Was previously affected		
Bundaberg Regional Council	Bundaberg	Bundaberg	Branyans WTP		WTP at Branyans is not operational - water is being sourced from the bore supplies, & is meeting restricted demand	The intake structure at Branyon WTP needs to be assessed for damage when water levels drop); - otherwise no major issues	Both ? STPs are operational, however: - Millbank STP is currently only treating to a primary standard - Bundaberg East STP is currently treating to secondary standard only	Both? plants are not providing full treatment due to high flows & water damaged chlorination equipment. Millbank is expecting to go to secondary treatment later this afternoon. A number of sewerage mains are damaged - but no major issues (overall sewer system is okay). Council is dealing with the damaged mains & there are no major disruptions to services	Waste management services are normal	Not having problems removing rubbish from streets or footpaths, Council is being assisted by SES and Council Parks Dept. crews. The main land fill in University Drive is presently taking most of the rubbish and has at least 2 years of dump area available
	Bargara	Bargara								
	Coral Cove	Coral Cove								
	Lake Monduran	Lake Monduran								
	Childers	Childers								
	Gin Gin	Gin Gin								
	Wallaville	Wallaville								
	Woodgate	Woodgate					Woodgate STP operational	Wet weather effluent storage lagoon is overflowing to Theodolite Creek.		
Central Highlands Regional Council	Emerald	Emerald	Emerald		WTP operational & producing normal volumes	water supply okay, no major issues	STPs are operational and sewerage systems okay, no major issues	Some pump stations are still being pumped out in readiness to be put back on line. Council is happy with progress.	The Emerald tip is nearly full but rubbish will then be trucked to Tieri landfill, which is about a 2.5 hours round trip.	No major problems, Council is being assisted by contractors (tip truck operators), Council is extremely busy with this. Council landfills are handling the waste.
	Capella	Capella	Capella		WTP operational & producing normal volumes	Running low on chlorine, a resupply is waiting to leave Rockhampton & should arrive before the chlorine runs out	STPs are operational and sewerage systems okay, no major issues	Some pump stations are still being pumped out in readiness to be put back on line. Council is happy with progress.		
	Springsure	Springsure								
	Blackwater	Blackwater								
	Park Avenue	Park Avenue								
	Tieri	Tieri								
	Bluff	Bluff								

Flood affected water services outside south east Queensland										
Local Govt	**Town**	**Flood affected Town/s**	**Water Supply Scheme**	**Connected Population**	**Status of Water supply**	**Comments**	**Status of Sewerage System**	**Comments**	**Status of Solid waste Disposal**	**Comments**
	Rolleston	Rolleston								
Cherbourg Aboriginal Council	Cherbourg	Cherbourg	Cherbourg		The water supply is now operational & producing sufficient water supplies.	Lost mains power to the water supply intake pumps and the WTP so two diesel generators were brought in. Mains power should be restored over the weekend. Also had a main break which has now been isolated. Restrictions are in place to manage demand. Road access between Cherbourg and Murgon has been restored this morning.	STP is operational	Some problems with pump stations which are being addressed.	No problems	
Fraser Coast	Maryborough	Maryborough	Maryborough		No problems reported		STP operational???	3 pump stations in the Maryborough sewage treatment plant catchment remain off line. Wide Bay Water envisages these stations will be back on line by COB Friday 14 January 2011.		
	Eli Creek	Eli Creek					Eli Creek and Pulgul Creek STPs are currently releasing treated effluent to waters, 24 hours a day, outside of license conditions.	Normally these plants irrigate 90% of treated effluent.		
	Pulgul	Pulgul								
	Toogoom	Toogoom					All other STPs are operating as normal.			
	Burrum Heads	Burrum Heads								
	Hervey Bay	Hervey Bay								
	Torbanlea	Torbanlea								
	Nikenbah	Nikenbah								
	Howard	Howard								
Goondiwindi Regional Council	Goondiwindi	Goondiwindi	Goondiwindi		Water supply are okay, no major issues	Should operate normally as long as the town levee prevents flooding of the town.	Sewerage systems are okay, no major issues	Should operate normally as long as the town levee prevents flooding of the town.	Waste management services everywhere are normal at present. Later on there could be problems outside the levee and perhaps at Yelarbon	
	Inglewood	Inglewood	Inglewood		not experiencing problems		not experiencing problems			
	Texas,	Texas,	Texas,		not experiencing problems		not experiencing problems			
	Talwood,	Talwood,	Talwood,		not experiencing problems		not experiencing problems			
	Toobeah,	Toobeah,	Toobeah,		not experiencing problems		not experiencing problems			
	Yelarbon,	Yelarbon,	Yelarbon,		not experiencing problems		not experiencing problems			
	Bungunyah	Bungunyah	Bungunyah		not experiencing problems		not experiencing problems			

Flood affected water services outside south east Queensland										
Local Govt	**Town**	**Flood affected Town/s**	**Water Supply Scheme**	**Connected Population**	**Status of Water supply**	**Comments**	**Status of Sewerage System**	**Comments**	**Status of Solid waste Disposal**	**Comments**
Gympie Regional Council	Gympie	Gympie	Gympie		WTPs are operational and producing normal volumes	Water supplies are okay, no major issues -	STPs are operational	Sewerage systems okay, no major issues some pump stations are still flood bound, but switchboards are being reinstalled as flood waters recede	No major problems - Council is being assisted by the army.	Council landfills are handling the waste. The main land fill in Gympie is presently taking most of the rubbish, some of the smaller tips are not accessible at the moment, but will be used when flood waters recede.
	Gympie Industrial	Gympie Industrial								
	Imbil	Imbil								
	Goomeri	Goomeri								
	Rainbow Beach	Rainbow Beach								
	Tin Can Bay	Tin Can Bay								
	Cooloola Cove	Cooloola Cove								
	Kilkivan	Kilkivan	Kilkivan		WTPs are operational and producing normal volumes	lost one bore at Kilkivan but the other 2 are functioning ok	??????????	?????????????		
Maranoa Regional Council	Roma	Roma	Roma		Water supplies are okay, no major issues	No serious issues reported	Sewerage systems okay, no major issues	No serious issues reported	Waste management services are normal.	
	Surat	Surat	Surat		Water supply ok	Expecting another flood peak about 19 January.	Sewerage ok	Expecting another flood peak about 19 January.		
	Mitchell	Mitchell				No serious issues reported		No serious issues reported		
	Injune	Injune								
	Amby,	Amby,					,			
	Jackson,	Jackson,								
	Muckadilla,	Muckadilla,								
	Mungallala,	Mungallala,								
	Wallumbilla	Wallumbilla								
	Yuleba	Yuleba								
North Burnett Regional Council	Eidsvold	Eidsvold								
	Gayndah	Gayndah								
	Monto	Monto								
	Mundubera	Mundubera								
	Biggenden	Biggenden	?????????????		All WTP's are operating on manual as there are some telemetry problems		All STP's are operating OK some Pump Stations are operating manually			
	Emu Park	Emu Park								
	Gracemere	Gracemere								

Flood affected water services outside south east Queensland										
Local Govt	Town	Flood affected Town/s	Water Supply Scheme	Connected Population	Status of Water supply	Comments	Status of Sewerage System	Comments	Status of Solid waste Disposal	Comments
Rockhampton	Mount Morgan	Mount Morgan								
	Rockhampton	Rockhampton			Flood waters have dropped 700 mm and flood level now @ 8.5 metres. No issues at WTPs, all operating		STP's are all functioning and operating OK, however still have access issues.		Rockhampton landfill will be inundated at predicted flood level	
	Yeppoon	Yeppoon								
th Burnett Regional Council	Boondoomba Dam	Boondoomba Dam								
	Murgon	Murgon								
	Wondai	Wondai								
	Proston	Proston								
	Blackbutt	Blackbutt								
	Kingaroy	Kingaroy								
	Nanango	Nanango			Operating normally		Operating normally.	STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).		
Southern Downs Regional Council	Wallangarra	Wallangarra								
	Leslie Dam	Leslie Dam								
	Warwick	Warwick								
	Rosenthal Heights	Rosenthal Heights								
	Dalveen	Dalveen								
	Killarney	Killarney								
	Stanthorpe	Stanthorpe			Operating normally		Operating normally			
Toowoomba Regional Council area	Toowoomba	Toowoomba			No serious issues reported		Wetalla STP no longer bypassing.	Missing section of 300mm sewer found downstream in Gowrie Creek. Council is recovering it and preparing to replace it with repairs at Griffiths St. Pumps operating as temporary repair to missing sewer main at North St.		
	Highfields and Crows Nest	Highfields and Crows Nest			No serious issues reported		STP and SPSs are operational with no bypass.			
	???????????				No serious issues reported		Loves Road (Wyreema) STP operational – with no bypass.			

Flood affected water services outside south east Queensland										
Local Govt	**Town**	**Flood affected Town/s**	**Water Supply Scheme**	**Connected Population**	**Status of Water supply**	**Comments**	**Status of Sewerage System**	**Comments**	**Status of Solid waste Disposal**	**Comments**
	Oakey	Oakey			No serious issues reported		Not operational???????	STP still has no power and the town has only one SPS operational. But council has found there is no break in sewer mains. Priority for council is to establish coarse screening and to restore operation of trickling filters.		
	??????	??????			No serious issues reported			Westbrook pump station N was overflowing yesterday and council has since engaged tanker contractor to recommence pump outs.		
Western Downs Regional Council	Dalby	Dalby	Dalby		WTP is inoperable due to Condamine flood ingress into clear water storage at the WTP. level 6 restrictions still apply.	There is currently 2-3 days supply in service reservoir storage. Commenced carting 0.5-0.7 ML day from Toowoomba. Predicted time for the flood to recede below the clearwater storage is Sunday 15 Jan and the WTP should be operating within 24 hrs of that. The WTP should be able to return to limited production capacity (2.5-3 ML/d, 200-300 Lpd). WTP should be operating at 60% of capacity by late today, treated water is still being tankered from Toowoomba.	sewerage system is functioning without bypass			
	Chinchilla	Chinchilla			WTP is operating at normal capacity	Precautionary 'boil water alerts' is current for residents	Chinchilla sewerage scheme is functioning OK although sub-optimal treatment.			
	Condamine	Condamine			Condamine is still totally evacuated. The WTP will be inundated again				Waste management service for Condamine is not functioning due to the difficulty of obtaining heavy vehicle permits from MRD.	Council is frustrated with inability to convince MRD that waste services is an essential service on the grounds of public health. Tara has not had waste collection for 3 weeks.
	Warra	Warra			Warra WTP continues to be inoperable due to flood damage and access problem. Drinking water is being tankered from Chinchilla					
	Jandowae	Jandowae			Previously affected water schemes are currently operating OK		Previously affected water schemes are currently operating OK			
	Meandarra	Meandarra							not functioning due to the difficulty of obtaining heavy vehicle permits from MRD.	
	Miles	Miles								
	Tara	Tara							Waste management service for Tara (i.e. accessed by the Moonie Highway from	
	Bell	Bell								
	Brigalow,	Brigalow,								
	Dulacca	Dulacca								
	Flinton,	Flinton,								
	Glenmorgan,	Glenmorgan,								

Flood affected water services outside south east Queensland										
Local Govt	**Town**	**Flood affected Town/s**	**Water Supply Scheme**	**Connected Population**	**Status of Water supply**	**Comments**	**Status of Sewerage System**	**Comments**	**Status of Solid waste Disposal**	**Comments**
	Jimbour,	Jimbour,			No serious issues are reported for Council's remaining schemes					
	Kaimkillenbun,	Kaimkillenbun,								
	Kogan,	Kogan,							Waste management service for Kogan (i.e.	
	Moonie,	Moonie,								
	The Gums,	The Gums,								
	Wandoan	Wandoan								
	Westmar	Westmar								
Woorabinda Aboriginal Council	Woorabinda	Woorabinda	Woorabinda		Bore 4 still operating OK at reduced capacity, normally 2 bores are required to meet demand	Water carting from Mimosa Creek has been able to be reduced to only one water tanker, access to the WTP has been improved with the construction of a temporary water main, such that the trucks now only use the bitumen pavement. The reservoir maintaining steady levels and currently @ 93% storage capacity (ie. 2 ML storage). The pump station wet-well intake at the Baralaba Weir has been inspected, however the duty pump is suspected to be blocked. There is still too much water in this vicinity to complete investigations. Council have contacted SunWater and are hoping to get this installation operational early next week - black soil conditions are even unsuitable for 4WD access and they will try access with a Quad vehicle next week, if needed. Electricians have checked Bore 3 which has been out of action for several months prior to this flood event. Electrics are OK, However, pump fault suspected or blockage to pump screens down borehole. Pump cuts in & out, however a lifting rig will be mobilised to investigate further once access conditions have improved	STP is operational	Sewerage system ok – no issues	No major problems apart from access problems for trucks	Only issue is the front end loader has broken down and they are awaiting parts from Rockhampton. Backhoe currently being used to push & cover rubbish

Flo[illegible]fected water services outside south east Que[illegible]nd				
Local Govt. flood affected	**Service**	**Serviced Towns**	**Status of Water supply**	**Status of Sewerage System**
Balonne Shire Council	**Water Supply**	- St George, Dirranbandi, Bollon, Thallon.	St George - the bore water supply scheme (direct into reticulation) is producing normal supplies Dirranbandi - WTP is operating at normal capacity. Bollon and Thallon - No serious issues	No expected failure of any sewerage pump stations or sewerage treatment plant at flood levels previously experienced. Wet weather storage capacity for treated effluent may not be sufficient if flooding is prolonged
	Sewerage			
Banana Shire Council	**Water Supply**	- Theodore, Taroom, Moura, Wowan, Biloela.	Scheme is at normal production Under a boil water alert which is expected to be lifted today pending results from QH	sewerage scheme is operating
	Sewerage			
Bundaberg Regional Council	**Water Supply**	Bundaberg, Bargara, Coral Cove, Lake Monduran, Childers, Gin Gin, Wallaville, Woodgate, Rolleston	WTP at Branyans is not operational - water is being sourced from the bore supplies, & is meeting restricted demand. The intake structure at Branyon WTP needs to be assessed for damage when water levels drop); - otherwise no major issues	Both ? STPs are operational, however: - Millbank STP is currently only treating to a primary standard - Bundaberg East STP is currently treating to secondary standard only Woodgate STP operational Wet weather effluent storage lagoon is overflowing to Theodolite Creek.
	Sewerage			
Central Highlands Regional Council	**Water Supply**	Emerald, Capella, Springsure, Blackwater, Park Avenue, Tieri, Bluff	WTP operational & producing normal volumes water supply okay, no major issues Capella running low on chlorine, a resupply is waiting to leave Rockhampton & should arrive before the chlorine runs out	STPs are operational and sewerage systems okay, no major issues Some pump stations are still being pumped out in readiness to be put back on line. Council is happy with progress.
	Sewerage			

Cherbourg Aboriginal Council	**Water Supply**	Cherbourg	The water supply is now ope[illegible]l & producing sufficient water supplies. Lost mains power to the water supply intake pumps and the WTP so two diesel generators were brought in. Mains power should be restored over the weekend. Also had a main break which has now been isolated. Restrictions are in place to manage demand. Road access between Cherbourg and Murgon has been restored this morning.	STP is operational Some problems with pump stations which are being addressed.
	Sewerage			
Fraser Coast	**Water Supply**	Maryborough, Eli Creek??, Pulgul??, Toogoom, Burrum Heads, Hervey Bay, Torbanlea, Nikenbah, Howard		No problems reported - STP operational???All other STPs are operating as normal. Eli Creek and Pulgul Creek STPs are currently releasing treated effluent to waters, 24 hours a day, outside of license conditions. 3 pump stations in the Maryborough sewage treatment plant catchment remain off line. Wide Bay Water envisages these stations will be back on line by COB Friday 14 January 2011. Normally these plants irrigate 90% of treated effluent.
	Sewerage			
Goondiwindi Regional Council	**Water Supply**	Goondiwindi, Inglewood, Texas, Talwood, Toobeah, Yelarbon, Bungunyah	Goondiwindi water supply are okay, no major issues; Should operate normally as long as the town levee prevents flooding of the town. All others not experiencing problems.	Goondiwindi sewerage systems are okay, no major issues; Should operate normally as long as the town levee prevents flooding of the town. All others not experiencing problems.
	Sewerage			
Gympie Regional Council	**Water Supply**	Gympie, Gympie Industrial, Imbil, Goomeri, Rainbow Beach, Tin Can Bay, Cooloola Cove, Kilkivan	WTPs are operational and producing normal volumes Water supplies are okay, no major issues - lost one bore at Kilkivan but the other 2 are functioning ok	STPs are operational Sewerage systems okay, no major issues - some pump stations are still flood bound, but switchboards are being reinstalled as flood waters recede

	Sewerage			
Maranoa Regional Council	**Water Supply**	Roma Surat Mitchell InjuneAmby,Jackson, Mungallala, Wallumbilla Yuleba	Water supplies are okay, no major issues No serious issues reported Expecting another flood peak about 19 January.	Sewerage systems okay, no major issues No serious issues reported Expecting another flood peak in Surat about 19 January.
	Sewerage			
North Burnett Regional Council	**Water Supply**	Eidsvold; Gayndah; Monto; Mundubera; Biggenden	All WTP's are operating on manual as there are some telemetry problems	All STP's are operating OK some Pump Stations are operating manually
	Sewerage			
Rockhampton	**Water Supply**	Rockhampton; Emu Park; Gracemere; Yeppoon; Mount Morgan	Flood waters have dropped 700 mm and flood level now @ 8.5 metres. No issues at WTPs, all operating normally to all water supply schemes.	STP's are all functioning and operating OK, however still have access issues.
	Sewerage			
South Burnett Regional Council	**Water Supply**	Boondoomba Dam MurgonWondai Proston Blackbutt Kingaroy	Operating normally	Operating normally. STP's in South Burnett are however hydraulically overloaded (as are most STPs in flood affected areas).
	Sewerage			
Southern Downs Regional Council		Wallangarra		
		Leslie Dam		
		Warwick		
		Rosenthal Heights		
		Dalveen		
		Killarney		

		Stanthorpe	Operating normally	Operating normally
Toowoomba Regional Council area		Toowoomba	No serious issues reported	Wetalla STP no longer bypassing. Missing section of 300mm sewer found downstream in Gowrie Creek. Council is recovering it and preparing to replace it with repairs at Griffiths St. Pumps operating as temporary repair to missing sewer main at North St.
		Highfields and Crows Nest	No serious issues reported	STP and SPSs are operational with no bypass.
			No serious issues reported	Loves Road (Wyreema) STP operational – with no bypass.
		Oakey	No serious issues reported	Not operational??????? STP still has no power and the town has only one SPS operational. But council has found there is no break in sewer mains. Priority for council is to establish coarse screening and to restore operation of trickling filters.
		??????	No serious issues reported	Westbrook pump station N was overflowing yesterday and council has since engaged tanker contractor to recommence pump outs.
		Dalby	WTP is inoperable due to Condamine flood ingress into clear water storage at the WTP. level 6 restrictions still apply. There is currently 2-3 days supply in service reservoir storage. Commenced carting 0.5-0.7 ML day from Toowoomba. Predicted time for the flood to recede below the clearwater storage is Sunday 15 Jan and the WTP should be operating within 24 hrs of that. The WTP should be able to return to limited production capacity (2.5-3 ML/d, 200-300 Lpd). WTP should be operating at 60% of capacity by late today, treated water is still being tankered from Toowoomba,	sewerage system is functioning without bypass

Western Downs Regional Council		Chinchilla	WTP is operating at normal capacity Precautionary 'boil water alerts' is current for residents	Chinchilla sewerage scheme is functioning OK although sub-optimal treatment.
		Condamine	Condamine is still totally evacuated. The WTP will be inundated again	
		Warra	Warra WTP continues to be inoperable due to flood damage and access problem. Drinking water is being tankered from Chinchilla	
		Jandowae	Previously affected water schemes are currently operating OK	Previously affected water schemes are currently operating OK
		Meandarra		
		Miles		
		Tara		
		Bell	No serious issues are reported for Council's remaining schemes	
		Brigalow,		
		Dulacca		
		Flinton,		
		Glenmorgan,		
		Jimbour,		
		Kaimkillenbun,		
		Kogan,		
		Moonie,		
		The Gums,		
		Wandoan		
		Westmar		

Woorabinda Aboriginal Council		Woorabinda	Bore 4 still operating OK at reduced capacity, normally 2 bores are required to meet demand Water carting from Mimosa Creek has been able to be reduced to only one water tanker, access to the WTP has been improved with the construction of a temporary water main, such that the trucks now only use the bitumen pavement. The reservoir maintaining steady levels and currently @ 93% storage capacity (ie. 2 ML storage). The pump station wet-well intake at the Baralaba Weir has been inspected, however the duty pump is suspected to be blocked. There is still too much water in this vicinity to complete investigations. Council have contacted SunWater and are hoping to get this installation operational early next week - black soil conditions are even unsuitable for 4WD access and they will try access with a Quad vehicle next week, if needed. Electricians have checked Bore 3 which has been out of action for several months prior to this flood event. Electrics are OK, However, pump fault suspected or blockage to pump screens down borehole. Pump cuts in & out, however a lifting rig will be mobilised to investiga	STP is operational Sewerage system ok – no issues

Flood affected water services outside south east Queensland					
Local Govt	**Town**	**Flood affected Town/s**	**Connected Population**	**Status of Solid waste Disposal**	**Comments**
Balonne Shire Council	St George	St George		No problems reported	
	Dirranbandi	Dirranbandi		No problems reported	
	Bollon	Bollon		No problems reported	
	Thallon	Thallon		No problems reported	
Banana Shire Council	Theodore	Theodore			Waste management services for Banana Shire council are normal
	Taroom	Taroom			
	Moura	Moura			
	Wowan	Wowan			
	Biloela	Biloela			
Bundaberg Regional	Bundaberg	Bundaberg		Waste management services are normal	Not having problems removing rubbish from streets or footpaths, Council is being assisted by SES and Council Parks Dept. crews. The main land fill in University Drive is presently taking most of the rubbish and has at least 2 years of dump area available
	Bargara	Bargara			

Council	Coral Cove	Coral Cove			
	Lake Monduran	Lake Monduran			
	Childers	Childers			
	Gin Gin	Gin Gin			
	Wallaville	Wallaville			
	Woodgate	Woodgate			
Central Highlands Regional Council	Emerald	Emerald		The Emerald tip is nearly full but rubbish will then be trucked to Tieri landfill, which is about a 2.5 hours round trip.	No major problems, Council is being assisted by contractors (tip truck operators), Council is extremely busy with this. Council landfills are handling the waste.
	Capella	Capella			
	Springsure	Springsure			
	Blackwater	Blackwater			
	Park Avenue	Park Avenue			
	Tieri	Tieri			
	Bluff	Bluff			

	Rolleston	Rolleston			
Cherbourg Aboriginal Council	Cherbourg	Cherbourg		No problems	
Fraser Coast	Maryborough	Maryborough			
	Eli Creek	Eli Creek			
	Pulgul	Pulgul			
	Toogoom	Toogoom			
	Burrum Heads	Burrum Heads			
	Hervey Bay	Hervey Bay			
	Torbanlea	Torbanlea			
	Nikenbah	Nikenbah			
	Howard	Howard			

Goondiwindi Regional Council	Goondiwindi	Goondiwindi		Waste management services everywhere are normal at present. Later on there could be problems outside the levee and perhaps at Yelarbon	
	Inglewood	Inglewood			
	Texas,	Texas,			
	Talwood,	Talwood,			
	Toobeah,	Toobeah,			
	Yelarbon,	Yelarbon,			
	Bungunyah	Bungunyah			
Gympie Regional Council	Gympie	Gympie		No major problems - Council is being assisted by the army.	Council landfills are handling the waste. The main land fill in Gympie is presently taking most of the rubbish, some of the smaller tips are not accessible at the moment, but will be used when flood waters recede.
	Gympie Industrial	Gympie Industrial			
	Imbil	Imbil			
	Goomeri	Goomeri			

	Rainbow Beach	Rainbow Beach			
	Tin Can Bay	Tin Can Bay			
	Cooloola Cove	Cooloola Cove			
	Kilkivan	Kilkivan			
Maranoa Regional Council	Roma	Roma		Waste management services are normal.	
	Surat	Surat			
	Mitchell	Mitchell			
	Injune	Injune			
	Amby,	Amby,			
	Jackson,	Jackson,			
	Muckadilla,	Muckadilla,			
	Mungallala,	Mungallala,			
	Wallumbilla	Wallumbilla			
	Yuleba	Yuleba			
	Eidsvold	Eidsvold			
	Gayndah	Gayndah			

North Burnett Regional Council	Monto	Monto			
	Mundubera	Mundubera			
	Biggenden	Biggenden			
Rockhampton	Emu Park	Emu Park			
	Gracemere	Gracemere			
	Mount Morgan	Mount Morgan			
	Rockhampton	Rockhampton		Rockhampton landfill will be inundated at predicted flood level	
	Yeppoon	Yeppoon			
	Boondoomba Dam	Boondoomba Dam			
	Murgon	Murgon			
	Wondai	Wondai			

South Burnett Regional Council	Proston	Proston			
	Blackbutt	Blackbutt			
	Kingaroy	Kingaroy			
	Nanango	Nanango			
Southern Downs Regional Council	Wallangarra	Wallangarra			
	Leslie Dam	Leslie Dam			
	Warwick	Warwick			
	Rosenthal Heights	Rosenthal Heights			
	Dalveen	Dalveen			
	Killarney	Killarney			
	Stanthorpe	Stanthorpe			

Toowoomba Regional Council area	Toowoomba	Toowoomba			
	Highfields and Crows Nest	Highfields and Crows Nest			
	???????????				
	Oakey	Oakey			
	??????	??????			

	Dalby	Dalby			
	Chinchilla	Chinchilla			
	Condamine	Condamine		Waste management service for Condamine is not functioning due to the difficulty of obtaining heavy vehicle permits from MRD.	Council is frustrated with inability to convince MRD that waste services is an essential service on the grounds of public health. Tara has not had waste collection for 3 weeks.
	Warra	Warra			
	Jandowae	Jandowae			
	Meandarra	Meandarra		not functioning due to the difficulty of obtaining heavy vehicle permits from MRD.	
	Miles	Miles			

Western Downs Regional Council	Tara	Tara		Waste management service for Tara (i.e. accessed by the Moonie Highway from Dalby) is not functioning due to the difficulty of obtaining heavy vehicle permits from MRD.	
	Bell	Bell			
	Brigalow,	Brigalow,			
	Dulacca	Dulacca			
	Flinton,	Flinton,			
	Glenmorgan,	Glenmorgan,			
	Jimbour,	Jimbour,			
	Kaimkillenbun,	Kaimkillenbun,			
	Kogan,	Kogan,		Waste management service for Kogan (i.e.	
	Moonie,	Moonie,			
	The Gums,	The Gums,			
	Wandoan	Wandoan			
	Westmar	Westmar			

Woorabinda Aboriginal Council	Woorabinda	Woorabinda		No major problems apart from access problems for trucks	Only issue is the front end loader has broken down and they are awaiting parts from Rockhampton. Backhoe currently being used to push & cover rubbish

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Key Developments
Recovery • **Regional officers met with the Northern Director of the Qld Reconstruction Authority and discussed recovery issues and assistance required. Issues identified included access to State Forest on the western side of Cardwell for town purposes, repair for jetty and marine transport infrastructure, coastal erosion repairs and waterway debris clean up activities. Officers continue to participate in built infrastructure and natural environment recovery group meetings to address specific recovery issues. Recovery groups have commenced preparing local recovery plans which document proposed actions.** • The wet season in North and Far North Queensland continues compounding and delaying recovery activities. Demand for departmental services from regional authorities is continuing. The department continues to provide support to communities affected by TC Yasi and the Queensland Reconstruction Authority in response and recovery activities. • Emerging issues include pest animal and weed management, fire risk assessments, advice requests for rehabilitation and clean up of waterways, monitoring vegetation clearing, beach restoration expectations and available financial assistance, and responding to diverse public expectations and sometimes strong opinions about management of natural resources as part of recovery activities. • The anticipated change in demand for regional services over the next 12 months is being assessed. Strategies will be developed to reduce application processing times and to provide concise information and advice to stakeholders to address emerging issues. • Officers of the department are participating in regional council led recovery subcommittees for environmental and infrastructure recovery.

Specific Issues		EMG Member	Date/Time
Streamflow Gauging Stations		Debbie Best	16/03/2011
	Response • The overall status of the DERM streamflow gauging station network is satisfactory. • The current status of the groundwater bore monitoring network is being assessed. Based on the reported impact to accessible sites it is expected there will be damage in flood affected areas where bores were inundated. • Assessment of the long-term/permanent repairs required to restore the streamflow gauging station and groundwater bore monitoring network commenced in January, and is expected to be completed by June 2011 when safe access to remote stations is possible. *Cyclone* • No further updates. *Metrics*: • **373** streamflow gauging stations are operated in the Declared Natural Disaster Area. *Of these:* • **129** gauging stations are operational – completed on-site assessment and operating at pre-event levels. • 50 gauging stations are operational – completed investigation or on-site assessment and		

'DERM-03'

Specific Issues		EMG Member	Date/Time
	preliminary repairs, require further restoration. • **185** gauging stations are operational – no on-site assessment and collecting data at pre-event levels • 2 gauging stations are non operational – completed on-site assessment and require re-build. • 7 gauging stations with status unknown – no on-site assessment and not communicating data. • 5 control weirs that provide stable flow conditions for gauging stations have been damaged and require repair.		
	Recovery • Preliminary repairs to ensure the continued operation of the gauging station network are being undertaken where possible with other restoration activities planned when access is available.		
Water Treatment Plants		Debbie Best	16/03/2011

	Recovery
	Floods
	SEQ
	• **No further updates**
	Outside SEQ
	• **No further updates**
	Cyclone
	• All boil water alerts have been lifted.
	• All areas – Water supply has been restored throughout the affected region but some systems are fragile and some individual properties are without water due to extensive damage.
	• Burdekin
	  • Milaroo - Repairs to a pump fault are expected to take up to 8 weeks, as it cannot be fixed until the river level drops. In the meantime water is being trucked **from Clare** to the reservoir and bottled water is available for residents.
	• Townsville
	  • The Paluma water treatment plant remains on generator power and will continue to be for some time.		

Sewerage Treatment Plants		Debbie Best	16/03/2011
	Recovery *Floods* SEQ • **No further updates** Outside SEQ		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
	• **No further updates** *Cyclone* • All sewerage, sewage treatment plants and pump stations are operational across the region, some of which are on generator power. • The region is monitoring the performance of STPs and any ongoing issues. • Cassowary Coast o Port Hinchinbrook - (Privately owned Sewerage Treatment System) - **The Williams Corporation's STP at Port Hinchinbrook is running on its own backup generator. The roof of the treated effluent storage tank was blown off and has not been replaced. All critical pump stations are operating although some pumps are working only slowly and are most likely due for replacement.** - **The main pump station that pumps to the STP is running on a generator provided by EMQ in Innisfail.** - **One pump station that services the residential area along the foreshore has been destroyed. Some residents may be moving back into the catchment of this pump station so repair is a high priority.** - **All treated sewage is currently being released into One Mile Creek as allowed in the STP approval. STP function and treatment is reported to be satisfactory.** - **Significant electrical repair work is required across the whole Port Hinchinbrook site. An electrician was on site 16 March to determine work required.** - **An inspection of the STP and pump stations will be carried out when weather conditions permit and access to the site is reinstated.**		
Waste Management		Mike Birchley	16/03/2011
	Recovery *Floods* • DERM's recovery of hazardous material containers within Oxley Creek, Stable Swamp Creek and Rocky Waterholes Creek: • **Works through the past week have continued and the project is drawing to a close, however the focus of works last week included vegetation assessments and clearing in order to access difficult locations.** • **Wet weather during the week also hampered recovery efforts and DERM does not have an update of containers removed at the time of writing.** • **50 out** of 57 grids have been reinspected following removal and certified cleared of hazardous material containers. Outside SEQ		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
	• No further updates *Cyclone* • Regional Service Delivery Environmental Staff took part in all of the regular Asbestos Sub Group meetings to provide support and advice on the matter. The last meeting was held on 28 February. • The clean up of Asbestos Related hazardous materials at Hull Heads **and Tully Heads** has been completed by Q Build. • DERM officers have highlighted that management of any residual asbestos material in the Hull / Tully Heads area which is identified on private and public land following the completion of the Q Build clean up will be the responsibility of individual property owners or the local authority. • Owners of Individual premises where Asbestos Related hazardous materials exist are being provided information by the councils and remain the responsibility of the individual property owners. • DEEDI has contacted the department to assist in the management of waste on Bedarra and Dunk Islands. **DERM officers have provided advice to** DEEDI that **all available waste management options need to be exhausted by the resort operators** to avoid the need to dispose of waste on Dunk Island. • **All waste management issues will now be managed through the local council recovery group.**		
Mapping and Spatial Information		Chris Robson	16/03/2011
	Recovery • **28 new flood maps over the towns of Bundaberg, Chinchilla, Dalby, Flinton, Jambin, Roma, Stanthorpe, Warwick and Woodford produced and sent to QRA and the Commission.** • **12 new Regional Catchment Maps covering the LGA's of Banana, Central Highland, Fraser Coast, Gympie, Isaac, Maranoa, North Burnett, Rockhampton, South Burnett, Southern Downs, Toowoomba and Western Downs produced and sent to QRA and the Commission** • **Running total of 640 flood and cyclone related maps created since 27 December 2010** • **The Queensland Government Information Service now has 140 flood images, and 19 flood line maps available for download. DERM is publishing imagery and data when it is provided to us.** • **Rockhampton imagery has been published. Emerald/Fairbairn Dam imagery is being published. Since being published, 105 flood images have been downloaded and 100 flood line maps.**		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
	• **Work to create the initial 350 disaster map records (approximately) in the Products And Service System (PASS) database has commenced.** • **This will provide a catalogue of information about the maps created for the 2011 Floods and for the cyclone Yasi event.** • **All imagery flown by ADF has been received by DERM and is progressively being processed – approximate timeframe of 2 weeks to complete.** • **Rockhampton imagery (Priority 1 area) revised and imagery available.** • **Rolleston imagery available** • **Esk, Cecil Plains, Biloela & Eidsvold imagery being processed** • **Completed flood/damage line for Helidon, Murphy's Creek, Postman's Ridge, Withcott and Grantham areas** • **Investigating revisions of Brisbane and Ipswich flood lines.** *Cyclone* • **22 new Cyclone maps over the towns of Innisfail, Kurrimine, Mena Creek, Mission Beach, Palm Island and Silky Oak produced and sent to QRA and the Commission** • **Running total of 640 flood and cyclone related maps created since 27 December 2010** • **Work to create the initial 350 disaster map records (approximately) in the Products And Service System (PASS) database has commenced.** • **This will provide a catalogue of information about the maps created for the 2011 Floods and for the cyclone Yasi event.** • **Final orthophotos have been received for Palm Island, Dunk Island, Halifax, Mena Creek and Ingham.**		
Parks and Wildlife		Andrea Leverington	16/03/2011
	Recovery • **No further updates available**		
Stakeholder engagement		Andrea Leverington	23/02/2011
	Recovery • No further updates.		
Environment		Mike Birchley	16/03/2011
	Response • The State Land Management team continues to remove debris from Unallocated State Land adjacent to residential areas and respond to enquiries from the public. • Initial clean up activities to remove loose debris from USL has been completed. Four officers continue to work on Magnetic Island to control emerging pest management issues.		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
	• Specialist contract work is now required to remove dangerous trees in urban areas. Repair work to 398 kilometres of firebreaks in the TC Yasi affected area is required at an approximate cost of $181 000. • Officers of the Cassowary Coast Regional Council have advised that the Clump Point Jetty and Dunk Island Jetties have been extensively damaged and the council is considering not owning or being responsible for the repair and ongoing maintenance of the structures. This could involve surrendering trusteeship of a Reserve for Local Government (boat harbour) at Clump Point and a lease over land adjoining the Dunk Island jetty. • **North Region officers participated in a meeting of the local built environment recovery sub group on 15 March 2011. Discussion focussed on activities required for recovery and officers encouraged the council to work on broader issues such as changes to existing infrastructure and management of the infrastructure once the infrastructure for essential services has been restored.** • **The council is preparing a short submission to the Qld Reconstruction Authority for replacement on a like for like basis of the jetty and pontoon at clump point. Further assessment and discussion is required by stakeholders regarding Dunk Island and Cardwell jetties. The council proposal to the Reconstruction Authority will also include a request for some resources to assist with planning for resilience of these facilities, including community consultation.**		
	Recovery *Floods* • The Port of Bundaberg submitted a voluntary TEP to provide for the placement of 65,000m^3 of dredge spoil in the channel of the Burnett River rather than in the usual sea dumping location. The TEP has been approved with conditions requiring that the dredge spoil must be monitored to determine if it will cause harm. The dredging was completed on Monday 28 February.		
Environmental Monitoring		Christine Williams	
	Response • No further updates		
	Recovery • No further updates		
Dam Safety		Dean Ellwood	02/03/2011
	Recovery • No further updates		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
Mines		Mike Birchley	16/03/2011
	Recovery • Situation updates on the impacts on mines and CSG operations are being supplied weekly as separate reports. • Cyclone Yasi overall: Northwest Queensland and the Northern Goldfields experienced moderate rains as a result of ex-Tropical Cyclone Yasi, with areas receiving between 25mm and 200mm. As a result of this rainfall, several sites have reported some releases of water, including Ernest Henry Mine (Cloncurry), Pajingo Gold Mine (Charters Towers), and Thalanga Copper Mine (Charters Towers). • Departmental officers are continuing to liaise with all sites to establish the impact Cyclone Yasi had on mine sites, and has responded to any issues based on the risk posed to the environment.		
Coal Seam Gas		Mike Birchley	16/03/2011
	Recovery • Situation updates on the impacts on mines and CSG operations are being supplied weekly as separate reports. • Cyclone Yasi overall: Northwest Queensland and the Northern Goldfields experienced moderate rains as a result of ex-Tropical Cyclone Yasi, with areas receiving between 25mm and 200mm. As a result of this rainfall, several sites have reported some releases of water, including Ernest Henry Mine (Cloncurry), Pajingo Gold Mine (Charters Towers), and Thalanga Copper Mine (Charters Towers). • Departmental officers are continuing to liaise with all sites to establish the impact Cyclone Yasi had on mine sites, and has responded to any issues based on the risk posed to the environment.		
Leases, Permits and Licences – Fee recovery		Chris Robson/Mike Birchley	16/03/2011
	Response *Flood* • The department has recommenced the issuing of invoices for Chapter 14 (Water usage charge) and Chapter 15 (Water Meter Service Charge) as of the week commencing 14 February 2011. • The department is continuing to issue invoices for Annual Returns and Annual Invoices under the *Environmental Protection Act 1994*. However, in recognition of the significant areas currently affected by flooding and the hardships experienced by some clients during this		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
	period, the department is providing additional support to clients offering them the ability to enter into a repayment agreement (a one month extension) or enter into a payment plan (eg. monthly payments) which will allow the client to split the lump sum payment into more manageable amounts. With compliments slips have been attached to each invoice and dunning letter advising the clients to contact the department if they feel they are unable to meet the payment terms or if they have any other questions. • INVOICES ISSUED: Since 4 January to 10:30am 9 March 2011 the department has issued: • **52** invoices to the value of $**1,252,875** for Chapter 5 Level 1 Mining; • **938** invoices to the value of **$479,415** for Chapter 5 Level 2 Mining; • **769** invoices to the value of **$4,875,513** for Chapter 4 Environmentally relevant activities; • **48** invoices to the value of **$525,953** for Chapter 5A Level 1 and 2 Gas and Petroleum; • **346** invoices to the value of **$987,441** for Sewerage Treatment Plants; and • refunds to the value of **$254,764**. Total Value = **$8,121,197** • ANNUAL FEE OR LATE FEE REMINDER LETTER (dunning letter) (sent out monthly - on the 5th day of every month covering 30 and 60 day overdue invoices): • As of 10:30am **10** March 2011 the department has issued 3669 dunning letters with a value of $810,675.54. • LATE FEES APPLIED: • As of 10:30am 9 March 2011 the department has applied late fees to **495** outstanding invoices to the value of **$51,088.**		
Forest Plantation Oversight issues		Chris Robson	29/02/2011
	Recovery • No further updates		
Aboriginal and Torres Strait Islander Land Services issues		Chris Robson	16/03/2011
	Recovery *Floods & Cyclone* • **Current wet in Far North is impacting on ATSILS business. The ability to work many areas is restricted. Judgement and commonsense is exercised through planning; staff have satellite phone as well as mobiles; and regularly call in to the office to advise where they are, current weather conditions and when they anticipate they will call in next.**		

DERM Joint Disaster Response/Recovery – 2010-11 Qld Floods & 2011 Cyclones Anthony & Yasi
Situation Report - 16 March 2011

Specific Issues		EMG Member	Date/Time
Heritage		Mike Birchley	16/03/2011
	Recovery *Cyclone* • The Cultural Heritage Coordination Unit has received a request for assistance in auditing and restoring cultural sites and walking trails in the Kennedy and Cardwell area damaged by Cyclone Yasi. Initial assistance is being provided via the North Regional Office and will include an on-site review by the Cultural Heritage coordinator and QPWS staff. • North Region officers have contacted 261 owners of 301 sites in the affected area listed on the heritage register to assess damage to listed assets. 189 sites have action completed and ten places have been identified with major structural damage which may result in some requests for demolition. Officers have arranged inspections of 72 places over coming weeks. 40 owners of low risk sites are still to be contacted. **Officers continue to work with owners of Cyclone affected sites.** • Twenty-two traditional owner groups with cultural heritage sites in the affected area have been contacted. No requests for assistance have been received, however this is likely to change once the wet season ends and site inspections by traditional owners are completed.		
Financial Impacts		Danielle Anderson	09/03/2011
	Recovery • **No further updates**		
Communication/ Media		Danielle Anderson	16/03/2011
	Recovery • **12 March - QPWS retrieved a 3 metre crocodile which fell into a machinery pit at Victoria Sugar Mill at Ingham "to get away from the rising waters".**		
Workplace Health and Safety		Danielle Anderson	
	Recovery • Nil response		

'DERM-04'

Report on Gauging Stations where Status is Unknown

116016A Rudd Creek at Gunnawarra
Gauging station 116016A on Rudd Creek is located in the upper reaches of the Herbert River catchment in Far North Queensland. Currently DERM is unable to reliably communicate with this station to download near-real time data. This communication problem is likely due to the strength signal from the mobile phone network. It is highly likely that this station is still operating satisfactorily and is logging data. Until such time as DERM's hydrographic officers can access this site to inspect its condition and to collect the data it is unlikely data will be available. BoM houses its own instrumentation within DERM's gauging station. BoM has used DERM's logging equipment when BoM's instrumentation has failed. BoM does not use DERM's communication infrastructure to access data

120107A Burdekin River at Blue Range
Gauging station 120107A is located on the Burdekin River in the upper reaches of the Burdekin Basin. This station failed on 28/12/2010 and DERM is currently unable to communicate with this station due to a landline telephone fault. DERM has been informed by the telecommunications provider that this fault is cannot be fixed. In order to re-establish reliable communications with this station DERM is in the process of procuring a satellite internet protocol communications system (this is new technology). Once DERM has received this equipment it will be installed on the site and near-real time data links will be re-established. It is highly likely that this station is still operating satisfactorily and is logging data. Until such time as DERM's hydrographic officers can access this site to inspect its condition and to collect the data it is unlikely data will be available. BoM houses its own instrumentation within DERM's gauging station. BoM has used DERM's logging equipment when BoM's instrumentation has failed. BoM does not use DERM's communication infrastructure to access data

416312A Oaky Creek at Texas
Gauging Station 416312A is located in Severn River catchment in the Border Rivers. Currently DERM is unable to reliably communicate with this station to download near-real time data. This communication problem is due to intermittent signal from the mobile phone network. BoM uses this site for flood warning purposes. DERM is investigating putting in place a permanent solution to the communication problem at this station.

422208A Culgoa River Woolerbilla
Gauging Station 422208A is located in the Balonne River catchment in the Condamine and Balonne Rivers Basin. Currently DERM is unable to reliably communicate with this station to download near-real time data. This communication problem is due to the failure of the landline. It is highly likely that this station is still operating satisfactorily and is logging data. Until such time as DERM's hydrographic officers can access this site to inspect its condition and to collect the data it is unlikely data will be available. DERM is investigating options to put in place a permanent solution to the communication issues. This station is not used by BoM for flood warning purposes and therefore it is not a DERM priority to confirm its status.

913007A Leichhardt River At Floraville Homestead

Gauging station 913007A is located within the Leichhardt River catchment in Queensland's Gulf country. Currently DERM is unable to reliably communicate with this station to download near-real time data. This communication problem is due to the strength of signal from the mobile phone network. It is highly likely that this station is still operating satisfactorily and is logging data. Until such time as DERM's hydrographic officers can access this site to inspect its condition and to collect the data it is unlikely data will be available. This station is used by BoM for flood warning purposes. DERM is investigating putting in place a permanent solution to the communication problem at this station.

'DERM-05'

CTS No. 00049/11

Department of Environment and Resource Management
MINISTERIAL BRIEFING NOTE

Advisor ..... OK
Dated / /
Approved Not Approved Noted
Further information required
Minister .....
Dated 5 / 1 / 11

TO: **Minister for Natural Resources, Mines and Energy and Minister for Trade**

SUBJECT: **Status of the statewide network of gauging stations operated by the DERM**

TIMEFRAME

- This brief has been supplied to inform the Minister of the status of the statewide network of gauging stations operated by the Department of Environment and Resource Management (DERM) for water assessment, planning and resource management purposes.
- Noting of this brief is required by **5 January 2011** to enable the Minister to inform Cabinet if required.

RECOMMENDATION

It is recommended that the Minister:

- **Note** that the network of gauging stations operated by DERM has held up well under extreme conditions.
- **Note** that thirteen (13) gauging stations are not operational and have known and unknown issues, seven (7) of which are used by the Bureau of Meteorology's (Bureau) flood warning operations (See Attachment 1). The Department continues to respond to and support the flood warning service of the Bureau and regional councils.
- **Note** that over the next eight days further heavy rainfall is predicted for the catchments already affected by flood (See Attachment 2).
- **Note** that the Bureau is predicting a 60-70% chance of exceeding median rainfall over south eastern Queensland over the next three months (See attachment 3).
- **Note** the critical next steps are to repair gauging stations where it is safe to do so or access is possible.

BACKGROUND

- The Bureau of Meteorology is responsible for flood warnings and forecasting. In flood times the Department of Environment & Resource Management (DERM) provides information and support to the Bureau to ensure the best available streamflow information is being used.
- DERM operates a statewide network of approximately 400 gauging stations across Queensland for water assessment, planning and resource management purposes.
- These stations collect, manage and deliver data on the quantity and quality of the state's rivers, streams and aquifers and includes stream height, flow and water quality information.
- The information from these sites is available to the Bureau of Meteorology, and together with details from their own gauging stations, information from water service providers such as SunWater and SEQWater, and regional councils, the Bureau is able to provide a flood warning service.
- The DERM network of gauging stations is fully automated, which means all information is provided by on site telemetry to a central system.

Author	Cleared by	Cleared by	Recommended:
Name: Ian White Position: Principal Policy Officer Water Monitoring and Information Tel No: [redacted] Date: 4/01/2011	Name: Ken Aitken Position: A/Dir Water Accounting Tel No: [redacted] Name: Graeme Milligan ENDORSED Position: GM Water Quality and Accounting Tel No: [redacted]	Name: Leslie Shirrefs Position: A/DDG Water and Ecosystem Outcomes Tel No: [redacted] Name: Position: Tel No:	Name: Debbie Best A/Director-General, DERM Tel No: [redacted] Date: 4.1.11

File Ref:

CURRENT ISSUES

- DERM staff have been in the field continuously since before Christmas Day undertaking measurements for these significant streamflow events and have been working closely with the Bureau's staff to make repairs to gauging stations where there is access and it is operationally safe to do so. The primary objective for DERM at this time is to ensure the operation of the gauging station network.
- Where there are known problems with the DERM network, the Bureau is informed. DERM remains in close contact with the Bureau to ensure any operational issues are understood.
- Some instruments have been flooded even though they are located above historic flood levels and/or damaged due to erosion caused by flood waters. DERM operate 258 gauging stations in the flood affected catchments and thirteen of these have been impacted (See Attachment 1). Seven of these are actively used in the Bureau's flood warning system. Two of these currently have access issues and site assessments will need to be made before it can be determined if repairs are possible. The other five are currently being investigated.
- In these extreme circumstances it is inevitable that instrumentation, installations and communications will breakdown. DERM continues to respond and support the Bureau and regional councils.
- Following a program of immediate, temporary repairs, an audit will be undertaken to assess the performance of each site and costs required to implement permanent repairs and/or replacement to gauging stations damaged by the floods. The timeframe will be driven by access issues, but is expected to be completed by 30 June 2011.
- Interruptions to data were minimal where the new telemetry was in place. Consideration will be given to fully upgrading the telemetry communication to improve system reliability as part of the audit process.
- BOM are predicting heavy rainfall over the next eight days in catchments already affected by flood and are also predicting a 60-70% chance of exceeding median rainfall over the next three months in southeastern Queensland.

RESOURCE/IMPLEMENTATION IMPLICATIONS

- There are short term resource costs to restore the network to operational standard.
- There will be costs associated with significant repairs, replacement or upgrading of telemetry which would be subject to consideration by CBRC.

PROPOSED ACTION

- The department will undertake the following:
  - Make temporary repairs to gauging stations on a priority basis and where access is possible and it is safe to do so, in consultation with the Bureau and the Department of Community Safety.
  - Undertake an audit of all gauging stations affected by the floods to determine if repairs or replacement are required.
  - Provide update reports to the Minister as information becomes available on the network's status.
  - Advise the Minister of the costs associated with restoring the network to it's former operational status and also advise the resources required to upgrade telemetry equipment and system support to improve reliability.

Author	Cleared by	Cleared by	Recommended:
Name: Ian White Position: Principal Policy Officer Water Monitoring and Information Tel No: [redacted] Date: 4/01/2011	Name: Ken Aitken Position: A/Dir Water Accounting Tel No: [redacted]	Name: Leslie Shirrefs Position: A/DDG Water and Ecosystem Outcomes Tel No: [redacted]	Name: Debbie Best A/Director-General, DERM Tel No: [redacted] Date:
	Name: Graeme Milligan Position: GM Water Quality and Accounting Tel No: [redacted]	Name: Position: Tel No:	

File Ref:

MINISTER'S COMMENTS

ATTACHMENTS

- 1 DERM network status
- 2 Bureau eight day forecast
- 3 Bureau national seasonal rainfall outlook
- 4 Minister's notes

Author	Cleared by	Cleared by	Recommended:
Name: Ian White Position: Principal Policy Officer Water Monitoring and Information Tel No: [redacted] Date: 4/01/2011	Name: Ken Aitken Position: A/Dir Water Accounting Tel No: [redacted]	Name: Leslie Shirrefs Position: A/DDG Water and Ecosystem Outcomes Tel No: [redacted]	Name: Debbie Best A/Director-General, DERM Tel No: [redacted] Date:
	Name: Graeme Milligan Position: GM Water Quality and Accounting Tel No: [redacted]	Name: Position: Tel No:	

File Ref:

'DERM-06'

CTS No. 01348/11

Department of Environment and Resource Management
MINISTERIAL BRIEFING NOTE

Advisor ..... OK
Dated 10/02/11
Approved Not Approved Noted
Further information required
Minister .....
Dated 11/2/11

TO: Minister for Natural Resources, Mines and Energy and Minister for Trade

SUBJECT: Request for advice – Queensland Gauging Stations (updates CTS 00566/11)

RECEIVED
MINISTERIAL OFFICE
09 FEB 2011

☐ MINISTER
☐ POL ADV
☐ MEDIA ADV
☐ PARL SEC
☐ ADMIN
☐ .....

REQUESTED BY

- Minister's Office in response to information provided in CTS 00566/11 (21 January 2011)

TIMEFRAME

- Noting of this brief is required as soon as possible.

RECOMMENDATION

It is recommended that the Minister:

- **notes** that this brief also includes information on the impact of Cyclone Yasi.
- **notes** that DERM has responded to virtually all requests since September 2010 to repair critical gauging stations in South East Queensland.
- **notes** the cost to enhance communication reliability at DERM's gauging stations is $2.4M.
- **notes** the cost to provide a secure flood alert system within the existing DERM gauging station network is $10M plus operating costs of $2M per annum.

BACKGROUND

- DERM operates 389 gauging stations across Queensland for water resource assessment, planning and management purposes.
- The Bureau of Meteorology (BoM) utilises over 2000 rainfall and streamflow stations throughout Queensland for flood warning purposes. These stations are operated by the BoM and a range of other entities, including DERM.
- As additional data are received from a phone download, the system routinely provides an update every 15 minutes from 338 of DERM's gauging stations to the BoM for its Flood Warning Service. The BoM also advises DERM if it requires any additional information and requests repairs to key gauging stations if problems are identified.
- Officers routinely visit all gauging stations to undertake maintenance and manually download data. Frequency of these visits depends on location and access, but is generally at least four times a year. Repairs to meet the BoM's priorities are undertaken as soon as practicable.
- DERM's gauging stations are routinely upgraded with new technology every eight years.
- This brief updates information provided in CTS 00566/11 - Queensland Gauging Stations

CURRENT ISSUES

- The operational status of gauging stations, particularly communications, can change regularly. This is most likely to occur in extreme conditions and can be as a result of damage to equipment, loss of power and communication issues either at the station or at the network provider (eg Telstra's mobile network being out of service or cloud cover affecting satellite reception). Attachment 1 shows status of the gauging station network at 3 February 2011.
- Most power and communication issues are resolved when these services come back on line and do not require action from departmental officers.
- There are 73 gauging stations in the Tropical North (North Tropical Coast and Gulf of

Rec'd - ODG - 4 FEB 2011

Rec-ODDG - 3 FEB 2011

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Carpentaria) relevant to Cyclone Yasi. The department has successfully communicated with 58 of these stations within the last 24 hours. It is likely that that the remaining 15 stations are still recording data but are not able to communicate as a result of service issues (eg damage to Telstra's mobile and phone networks).

- The department has not received any requests from the BoM for priority repairs to any of the stations in the Tropical North. DERM staff in the region are yet to return to work and so Central Office is checking the operational status of those gauging stations daily. Any assessments and repairs will be undertaken as soon as practical. Regular updates will be provided on an ongoing basis until the situation normalises.
- There are 258 gauging stations in the South East, South West and Central West Region. As of 21 January after the peak of the South East floods DERM successfully communicated with 229 of these stations. Of the remaining 29 stations, 26 could be used by the BoM. See Attachment 2, table 2 for detailed information on the date of station failures, date of stations repairs and whether the stations are used by the BoM or not.
- Since September 2010, 12 requests from the BoM were received for repairs at gauging stations identified by them. A common problem requiring repair was communications, as many stations use traditional phone lines or mobile phone services, which can be adversely affected in severe weather events and record floods. Virtually all of these problems were rectified and BoM acknowledged DERM's timely efforts. Note BoM does not routinely comment on the performance of other agencies.
- Where possible repairs have been undertaken with 10 sites fully functional,1 collecting data with no communications (pre-existing communication issues with upgrade scheduled by 30 June 2011) and 1 requiring repair (scheduled for the week commencing the 7 February 2011). See Attachment 2, table 1 for detailed information.
- To provide secure flood warning capability at DERM gauging stations, the BoM or local governments would need to add duplicate instrumentation and communications system.
- DERM's Hydrographic Support Unit located at Rocklea provides technical support to the gauging station network and holds spare equipment. This facility was inundated in the January flood and critical instrumentation was removed prior to flooding, including a computer system relocated to Central Office. The facility is currently using a generator to undertake priority repairs and support critical systems, however further progress is dependent on QBuild to undertake repairs. Central Office is supporting routine requests for instrumentation normally administered by the Unit.

RESOURCE/IMPLEMENTATION IMPLICATIONS

- During Queensland's flooding the requirements to maintain the gauging station network stretched DERM's hydrographic resources. This is primarily as a result of the record water levels which inundated some sites, and the requirement to use a backup computer system when Mineral House was off line due to power outages. Also some key staff were personally impacted with their properties flood affected. Some assistance from external agencies is being utilised with the New South Wales Department of Energy and Water providing hydrographic and system support staff.
- Repair to the gauging station network has been included in the department's application for Natural Disaster Relief funding of $6M for the gauging station network and $1.5M to $2M for the groundwater monitoring network. This includes funding for specialised construction teams to carry out civil works.
- Overcoming communication problems will greatly enhance gauging station reliability to transmit data. Some 153 stations of interest to BoM have real time internet protocol data, which is quite reliable. To upgrade communications at the other 185 sites of interest to BoM would cost $1.8M plus a write-of of the residual asset value of $0.55M.

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- Even with reliable communications, other elements of a gauging station can fail, for example the measuring tube anchored in the stream can be washed away. The only way to ensure data is available in real time is to install duplicate instrumentation and communications in each station. The estimated cost to do this for all 338 sites (where practical) is $10M plus operating costs of $2M per annum. The duplicate system would be similar to the radio-telemetry ALERT systems operated by certain local authorities in South East Queensland, Central Highlands, Wet Tropics and the Pioneer Valley.

PROPOSED ACTION

- Staff will continue to repair all gauging stations that are not fully functional (where safe access allows), with priority given to the BoM's requests.
- In light of the recent floods and to inform future investment decisions by DERM on future formal agreement to clarify roles and responsibilities, the department proposes to facilitate a review of the statewide stream gauging network, including its asset replacement program. This will be undertaken in consultation with the BoM, other stream gauging entities and the Queensland Flood Warning Consultative Committee, which is chaired by Emergency Services Queensland.
- The department is preparing a Water Monitoring Recovery Plan to address issues identified during the recent event and aligns with the department's Synchronised Queensland Reconstruction Road Map. An interim report will be provided by 7 February 2011 and the final report within four months.

OTHER INFORMATION

- *Key Communication Messages:* A media enquiry has been received from the Courier Mail regarding the operation of a gauging station at Murphy's Creek/Spring Bluff on 10 January 2011, and about the operation and maintenance of the department's gauging stations more generally. A media response has been prepared by the department.
  Key messages include:
  - the department's streamflow gauging network was established for water assessment and management purposes; and
  - information from DERM stream gauging stations can be used by the BoM as part of the BoM's flood warning service and priority is given to responding to repair and data requests from the BoM.

MINISTER'S COMMENTS

ATTACHMENTS
Attachment 1 - DERM Queensland Gauging Station Telemetry and Operational Status
Attachment 2 - Request for advice – Queensland Gauging Stations

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'DERM-07'

23 FEB 2011

Queensland Government

Ref CTS 01871/11

Department of
Environment and Resource Management

Dr Greg Ayers
Director of Meteorology
Bureau of Meteorology
PO Box 1289
MELBOURNE VIC 3001

Dear Dr Ayres

Status of Queensland Government Stream Gauging Stations

As you would be aware, the Department operates the Queensland Government's network of 389 stream gauging stations. As data from many of these stations are used by the Bureau for flood warning purposes, I am updating you on the status of the network following recent floods across the State.

While the network generally performed satisfactorily during this testing time, there were a number of instances where failures occurred, making the data unavailable in real time or near real time. Some failures were due to the record flood levels, resulting in power loss or structural damage to stations. Most failures were due to technical communication losses. These were generally related to problems with our telecommunications network service provider. Responses to requests from the Bureau were acted on as a matter of the highest priority and all issues were resolved when safe access could be achieved. Please don't hesitate to advise me if the Bureau has any concerns with the current level of support provided by DERM or responsiveness to the Bureau's requests to repair infrastructure critical to the flood warning network. If necessary, we can negotiate alternate operational arrangements.

The stream gauging station network uses various technologies to communicate data, including phone line, mobile and satellite internet protocol systems. Each of these technologies has advantages and limitations, with their suitability determined on a station by station basis. The department's asset management schedule aims to progressively modernise the network instrumentation, including communication technologies, in order to improve reliability of data access. I acknowledge the funding provided by the Bureau under the Modernisation and Extension of Hydrological Monitoring Systems Program to expedite these upgrades. Details relating to these scheduled upgrades are included in the enclosed material. I would appreciate the Bureau's endorsement of the current approach.

I understand that the Bureau will be preparing a review of the adequacy and location of its gauging station network. DERM will provide assistance to this review and the results of the review will assist in our future investment decisions to ensure maximum support to the Bureau in their flood warning role.

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I am keen for the department to provide the maximum support to the Bureau in this regard and would appreciate any feedback on the department's support to date.

Should you have any queries on this matter, please contact Mr Greg Long, Director Water Accounting on telephone [redacted]

Yours sincerely

[redacted]

John Bradley
Director-General

'DERM-08'

Guidelines on Acceptable Flood Capacity for Dams

February 2007

Contents

1 Purpose, scope and structure of the guidelines

Dams play a vital role in our lives. They meet demand for drinking, irrigation and industrial water supply; they control floods, increase dry-weather flows in rivers and creeks and give opportunities for various recreational activities. But besides being a valuable resource, dams can also be a source of risk to downstream communities with dam failure potentially resulting in unacceptable damage to property and loss of life. One of the main causes of dam failure is the overtopping of dams because of inadequate flood carrying capacity.

S.491 (4A) of the *Water Act 2000* empowers the chief executive of the Department of Natural Resources and Water (NRW) to issue guidelines for applying safety conditions to referable dams. This document is a guideline issued by a duly authorised delegate of the chief executive pursuant to s.491 (4A). Dam safety conditions in relation to flood adequacy will be applied to referable dams in accordance with these guidelines.

The aim of these guidelines is to present the Queensland Government's flood adequacy policy against which all referable dams in Queensland will be assessed and to alert the dam owners to their wider responsibilities and liabilities in ensuring the safety of their dams.

The general principle is that a dam whose failure would cause excessive damage or the loss of many lives should be designed to a proportionally higher standard than a dam whose failure would result in less damage or fewer lives lost.

These guidelines relate to the flood safety of water dams, and more specifically, to the selection of an Acceptable Flood Capacity (AFC) and adequate spillway provisions for all proposed and existing referable dams in Queensland[1].

These guidelines detail the:

- available methods for determining the required flood discharge capacity for referable dams
- procedures to be followed when applying these methods
- reporting requirements when reporting the results of these investigations to the chief executive of NRW
- timeframe for any necessary dam safety upgrades.

These guidelines present three methods for assessing AFC for referable dams:

- Small dams standard
- Fall-back option
- Risk assessment procedure (incorporating ALARP).

The *Small dams* standard is a method, which allows the owners of small earth dams to quickly assess spillway adequacy. It is essentially a simplified "Fall-back" method, which relates the Acceptable Flood Capacity directly to the population at risk.

The *Fall-back* option is intended for larger dams where the cost of undertaking a full risk assessment is not warranted when weighed against the potential benefits.

[1] Under the *Water Act 2000, referable dams* are those assessed using *NRW's Guidelines for Failure Impact Assessment of Water Dams (NRM, 2002b)* as having a population at risk of 2 or more in the event of any potential failure of the dam.

In terms of safety, the traditional engineering approach has always been to specify the required flood discharge capacity for the dam at the design stage based on the relevant hydrological data and flood estimating and flood routing procedures. Hydrologic safety was considered separately from other risks, which resulted in identification of inadequate spillway capacity as a major cause of dam failure.

More recent risk based approaches, such as that put forward by ANCOLD (ANCOLD 2003), indicate that hydrological safety should be assessed within the total load context in order to identify the priority of dam safety inadequacies and dam failure scenarios. Dam failure scenarios may include (but are not limited to) piping at dam headwaters elevated by flood, spillway malfunction or severe scour at lesser floods than extreme.

The risk assessment procedure is based on the ANCOLD risk assessment process and is consistent with the framework of the national standard AS/NZS 4360:2004 Risk Management. It is a comprehensive tool intended to enable the dam owner to evaluate the deficiencies and available risk reduction options. This type of assessment should be adopted for major dams. The risk assessment procedure provides the owner with a review of the adequacy of the dam under all load conditions and failure scenarios, not just flood loadings. It also has the capability to more realistically assess the Acceptable Flood Capacity of gated spillway operations and the likelihood of premature failure due to causes such as spillway erosion.

Dam owners should note that, while these Guidelines set minimum requirements to protect the interests of the community, it is the responsibility of the owner to ensure the safety of dams, including their investigations, design, construction, operation, safety review and remediation.

Dam owners should realize that many of the rainfall estimates from years past are well below current estimates. In many cases the design floods may change over time as the techniques for determining extreme rainfalls are progressively refined and more detailed flood studies are undertaken for each dam.

It is the dam owners prerogative to adopt a higher safety standard where the owner considers that this is necessary from a business risk perspective.

Dam owners should also note that these guidelines set out the normal requirements of the chief executive of NRW. Where dam owners believe that a departure from these normal requirements is warranted, they should submit proposals for the chief executive's consideration with reasons in support of the proposed departure.

2 Requirements of the *Water Act 2000*

The *Water Act 2000* (the Act) provides the regulatory framework for dam safety of water dams in Queensland. Under s.491 of the Act the chief executive has the power to impose safety conditions on constructed referable dams, regardless of whether or not the dam owner already has a development permit for the dam. The chief executive also has the power under s.492 to change those safety conditions. Safety conditions imposed or changed by the chief executive are taken to be part of a development permit approving the construction of the dam.

The Act also refers to the guidelines, which may be issued and used by the chief executive in the process of applying safety conditions to a referable dam. These guidelines are such guidelines and they apply to all referable dams in Queensland including all referable gully dams, hillside storages and ring tanks.

The *Queensland Dam Safety Management Guidelines* (NR&M 2002a) and the *Guidelines for Failure Impact Assessment of Water Dams* (NR&M 2002b) have already been issued by NRW and should be read in conjunction with these guidelines. In applying these guidelines, it should be noted, that they are intended to form the basis for safe practices and to provide a consistent approach in the assessment of the safety of referable dams in Queensland.

References to other guidelines issued by NRW are to be taken as a reference to any updated version of those guidelines where the context permits.

3 Methodology to determine Acceptable Flood Capacity

3.1 General

All referable dams are required to have sufficient flood discharge capacity to pass the following:

(a) the Acceptable Flood Capacity without failure of the dam[2]

(b) a Spillway Design Flood without any damage to the dam

Where the selected Spillway Design Flood discharge is less than the Acceptable Flood Capacity, the potential impacts of floods in excess of the Spillway Design Flood up to the magnitude of the Acceptable Flood Capacity shall be identified, quantified and documented in the written Acceptable Flood Capacity Assessment report (Appendix A). Such potential impacts shall include detailed assessments of:

(a) how the magnitude of the adopted spillway design flood was determined and why it is considered acceptable

(b) the probability of the floods greater than the spillway design flood occurring and the potential there is for damage and loss of life caused by such floods

(c) the consequences of flows in excess of the spillway design flood and the impact of the higher flow velocities and greater water depths on various parts of the dam structure

(d) the potential damage to the dam caused by these flows and how the energy from these flows is dissipated

When assessing the flood discharge capacity of existing dams, the existing flood discharge capacity shall be taken as the flood discharge capacity that can be discharged without failure of the dam in its current arrangement.

These *Guidelines on Acceptable Flood Capacity for Dams* are based on a range of ANCOLD and other guidelines as listed below:

- *Selection of Acceptable Flood Capacity for Dams* (ANCOLD, 2000a),
- *Assessment of the Consequences of Dam Failure* (ANCOLD, 2000b)
- *Risk Assessment* (ANCOLD, 2003)
- *Guide to Flood Estimation* (AR&R 1999, Nathan, R. J. and Weinmann, P.E).

As most of the processes from the relevant ANCOLD and AR&R 1999 guidelines are not repeated here, it is important that the above documents are read in conjunction with these guidelines. In particular, where issues are not specifically addressed in these NRW Guidelines on Acceptable Flood Capacity, the relevant sections of the referenced ANCOLD guidelines apply.

The combined inflows into the storage from all sources should be taken into account when assessing the required spillway capacity. This combined inflow should include all natural inflows as well as inflows from water harvesting and from diversion channels.

The combined discharge capacity of all spillways can be taken into account when assessing a dam's flood discharge capacity. However, unless it can be clearly demonstrated that outlet works or hydropower stations can be reliably operated during flood events, the discharge capacity of these structures is to be ignored when assessing discharge capacity during floods.

[2] Under the *Water Act 2000*, failure of a referable dam is defined as:
(a) the physical collapse of all or part of the dam; or
(b) the uncontrolled release of any of its contents.

When requested, a written Acceptable Flood Capacity Assessment Report must be prepared by a Registered Professional Engineer of Queensland (RPEQ) for the current dam arrangement and submitted to NRW. Appendix A outlines the requirements for the Acceptable Flood Capacity Assessment Report.

Dam owners should ensure that their dam can safely pass floods up to the Acceptable Flood Capacity. Also the following characteristics or features for the spillway and outlet works where appropriate should be demonstrated:

(a) adequate resistance to erosion and cavitation

(b) adequate wall height to retain the flows

(c) adequate energy dissipation to prevent undermining or other erosion

(d) adequate resistance to uplift and other hydraulic forces on the spillway during the passage of floods

(e) capability to pass floating debris as required to ensure the unimpeded operation of the spillway

(f) adequate safety from landslides and scour

(g) adequate capacity to avoid restriction of the discharge capacity from debris build-up in the spillway approach channel and outlet channels.

In addition, where appropriate, the dam owner should ensure:

(h) Spillway gates and other control devices will operate with sufficient flood discharge capacity under all design conditions.

(i) Spillway gates, outlet works and other discharge control devices operate reliably. The reliability of discharge control operating mechanisms (including power supply, control and communication) should be commensurate with the hazard category involved and the time available during major floods to repair them or operate them by other means should problems occur. The reliability should be reflected in the determination of discharge capacity available to pass the Acceptable Flood Capacity.

(j) Unless a case for a contrary view is adequately made, where fuse plugs or fuse gates are relied upon to pass the Acceptable Flood Capacity, they should be appropriately designed, constructed and maintained in order to fulfil their required function in accordance with the following:

- Initial triggering of the fuse element is not to occur for floods having greater probability than 0.2 per cent AEP
- Failure of successive fuse plugs or fuse gates is to be progressive, predictable and designed to minimise the impact on downstream Population at Risk (PAR);
- The potential downstream impacts of fuse plug or fuse gate triggering at representative locations of PAR are to be identified and documented as part of the Acceptable Flood Capacity report (detailed in Appendix A).

Unless varied by the above, the design of fuse plugs is to comply with the provisions of US Department of the Interior (USBR 1987), *Guidelines for Using Fuse-plug Embankments in Auxiliary Spillways*.

(k) Where stoplogs or flashboards are the primary discharge control mechanism, they are designed to:

- be removed under conditions which overtop the stoplogs or flashboards, or

- be removed prior to the onset of any flood, or
- reliably fail under the flood loadings.

The spillway discharge capacity adopted for the Acceptable Flood Capacity Assessment Report should reflect the option adopted.

(l) all components are designed to withstand the appropriate earthquake loadings[3]

(m) assured access to all necessary locations on the dam for necessary operations during a flood event.

(n) a discharge capacity that will not be compromised by the failure of any structure across the spillway, its approach channel or its outlet channel.

More details on each of the three assessment methods are provided below.

3.2 Small dams standard

This assessment method may be used for any referable dam in Queensland having:

- a zoned or relatively homogeneous earthen embankment less than 12 metres high
- a PAR of 15 or less
- uncontrolled spillways[4]
- depths of flooding of PAR of less than three metres and the product of the depth of flooding and the average flow velocity is less than 4.6 m^2/sec.

It is expected that such levels of flooding are unlikely to occur for dams less than 12 metres high unless the discharge is severely concentrated in downstream channels or where the PAR is located in very close proximity to the dam.

This method is also not to be used for dams relying on spillways controlled by gates or other mechanical discharge control structures to pass the Acceptable Flood Capacity. For dams outside the parameters described above, only the fall-back option or the risk assessment procedure should be used.

The following steps are to be applied in the small dams standard assessment process:

1. Determine the maximum incremental PAR for any potential dam failure condition by following the procedures outlined in the *Guidelines for Failure Impact Assessment of Water Dams* (NR&M, 2002b) for a range of flood failure conditions up to the 1:20 000 Annual Exceedance Probability (AEP) flood event.

   Note: If the incremental PAR is greater than 15 for any of the flood failure conditions, this 'small dams standard' cannot be used to determine the AFC and one of the other methods must be used.

2. Determine the AEP of the required Acceptable Flood Capacity rainfall event by applying the maximum PAR to the graph presented in Figure 1:

$$AEP = \left(1/_{PAR}\right) \times 10^{-3}$$

[3] Until a Queensland guideline is developed on earthquake loadings for referable dams, the *ANCOLD "Guidelines for Design of Dams for Earthquake", August 1998* (ANCOLD 1998) should be applied.

[4] In this context, an 'uncontrolled spillway' is one which does not rely on flow through spillway gates or other mechanical discharge control structures to pass the Acceptable Flood Capacity.

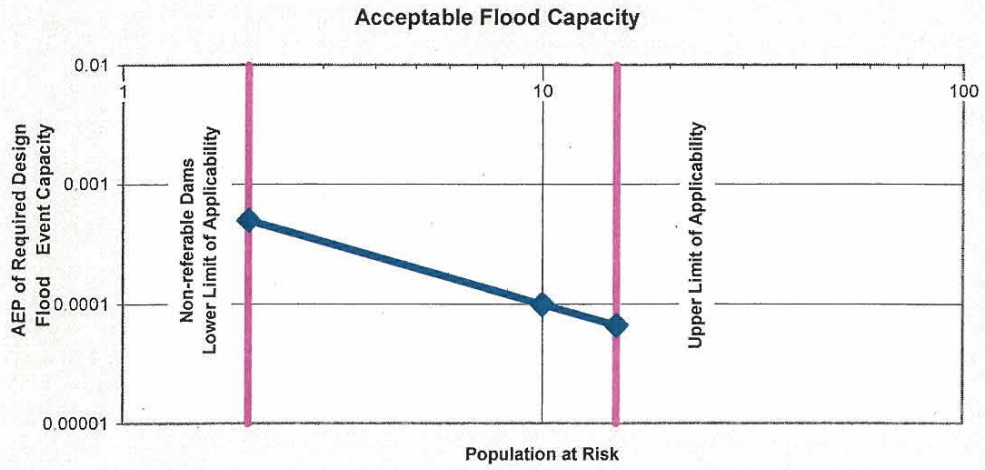


Figure 1 Acceptable flood capacity standard for small dams

3. Determine the storage inflow hydrograph for the critical duration storm event commensurate with the AEP of the design flood event rainfall as determined in Figure 1 (Refer Section 3.5);
4. Route this flood through the dam.

Note that it is to be assumed that the dam storage is initially at Full Supply Level (FSL) at the start of the flood event.

The required Acceptable Flood Capacity (AFC) for the dam is the discharge capacity required to pass the critical duration storm event without causing failure of the dam.

Note that this option does not take into account:

(a) Any differentiation between new and existing dams;

(b) Financial, business, social or environmental damages that might occur as a result of any potential failure;

(c) The ALARP principle.

This small dams standard is a simplified version of the fall-back option assessment process and as such, should be less costly to undertake than either of the alternative methods. However, small dam owners must be aware that they could benefit by carrying out one of the other more detailed assessment methods by perhaps demonstrating that a lower flood discharge capacity is appropriate for their dam.

3.3 Fall-back option

Except as modified in these guidelines, the following documents should be adopted and used for this method:

- ANCOLD *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD 2000a);
- ANCOLD *Guidelines on Assessment of the Consequences of Dam Failure* (ANCOLD 2000b); and
- NRW *Guidelines for Failure Impact Assessment of Water Dams* (NRM, 2002b).

The following steps are to be applied to the fall-back option assessment process:

1. Conduct an assessment of the potential consequences of dam failure associated with the passage of a range of design floods through the storage using the consequence criteria contained in the ANCOLD *Guidelines on Assessment of the Consequences of Dam Failure* (ANCOLD, 2000b) and the following qualifications:
   - The dam is to be assumed to be initially at Full Supply Level at the start of the flood event;
   - Breach dimensions, timing and PAR are to be determined in accordance with the NRW *Guidelines for Failure Impact Assessment of Water Dams* (NR&M, 2002b).
2. Determine the Hazard Category rating for the dam for each case in accordance with Table 1:

<table>
<tr><th rowspan="2">Incremental Population at Risk (PAR)</th><th colspan="4">Severity of Damage and Loss</th></tr>
<tr><th>Negligible</th><th>Minor</th><th>Medium</th><th>Major</th></tr>
<tr><td>$2 \leq PAR \leq 10$</td><td>Low
Notes 1</td><td>Significant
Note 5</td><td>Significant
Note 5</td><td>High C
Note 6</td></tr>
<tr><td>$10 < PAR \leq 100$</td><td rowspan="3">Note 1</td><td>Significant
Notes 2 and 5</td><td>High C
Note 6</td><td>High B
Note 6</td></tr>
<tr><td>$100 < PAR \leq 1000$</td><td rowspan="2">Note 2</td><td>High A
Note 6</td><td>High A
Note 6</td></tr>
<tr><td>$PAR > 1000$</td><td>Note 3</td><td>Extreme
Note 6</td></tr>
</table>

Table 1: Hazard Category for Referable Dams

(Please Note: Table 1 is a modified version of Table 3 Hazard Categories in the, Guidelines on Assessment of the Consequences of Dam failure (ANCOLD, 2000b.)

Note 1: It is unlikely that the severity of damage and loss will be "Negligible where one or more houses are damaged.

Note 2: Minor damage and loss would be unlikely when PAR exceeds 10.

Note 3: Medium damage and loss would be unlikely when the PAR exceeds 1000.

Note 4: Not used.

Note 5: Change to High C where there is the potential for one or more lives being lost.

Note 6: See section 2.7 and 1.6 in the Guidelines on Assessment of the Consequences of Dam failure (ANCOLD, 2000b) for an explanation of the range of High Hazard Categories.

3. Identify the required range of the Annual Exceedence Probability (AEP) flood for the dam in accordance with Table 2 [based on Table 8.1 in the *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD, 2000a)]:

Incremental Population at Risk (PAR)	Severity of Damage and Loss				
	Negligible	Minor	Medium	Major	
$2 \le PAR \le 10$	Low	Significant	Significant	High C	$1.0x10^{-5}$
		$5.0x10^{-4}$	$5.0x10^{-4}$	$1.0x10^{-4}$	C
		$5.0x10^{-4}$	$1.0x10^{-4}$	$1.0x10^{-4}$	
$10 < PAR \le 100$		Significant	High C	High B	$1.0x10^{-5}$
		$1.0x10^{-4}$	$1.0x10^{-4}$	C	B
		$1.0x10^{-4}$	C	B	B
$100 < PAR \le 1000$			A	A	A
			High A	High A	
			A	A	A
$PAR > 1000$	If in this region, go to the next highest severity of Damage and Loss category for the same PAR			PMF	PMF
				Extreme	
				PMF	PMF

Where

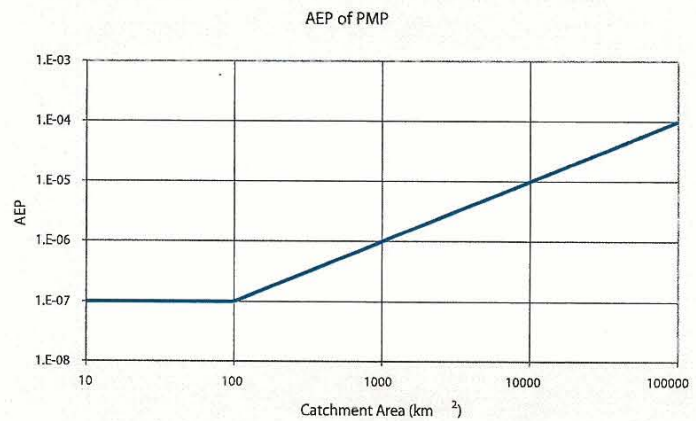
A = PMP Design Flood

B = PMP Design Flood or 10^{-6}, whichever is the smaller flood event

C = PMP Design Flood or 10^{-5} whichever is the smaller flood event

Note that the probability of the PMP Design Flood is a function of the catchment area.

Table 2: Required range of A cceptable Flood Capacities for different hazard categories



4. Interpolate (using the procedure defined in Appendix C) within the nominated range to determine the required Annual Exceedence Probability (AEP) for the spillway design flood for each failure case.
5. Determine the required AEP of the "critical duration design flood event rainfall" by selecting the flood event having the lowest AEP in Step 4.
6. Determine the storage inflow hydrograph for the critical duration design flood event commensurate with the AEP of the design flood event rainfall (Refer Section 3.5).

   Note that it is to be assumed that the dam reservoir is initially at Full Supply Level at the start of the flood event.

The required Acceptable Flood Capacity (AFC) is the discharge capacity required to pass the critical duration storm event without causing failure of the dam.

Note: The owner of the dam should be aware that the fall-back method may result in a higher design requirement and consequent higher cost of the upgrade required to bring it up to the required standard than the alternative risk assessment procedure (incorporating ALARP).

3.4 Risk assessment procedure

Except as modified in these guidelines, the Acceptable Flood Capacity Assessment based on the risk assessment procedure should be carried out in accordance the following guidelines:

- ANCOLD *Guidelines on Selection of Acceptable Flood Capacity for Dams* (ANCOLD, 2000a)
- ANCOLD *Guidelines on Assessment of the Consequences of Dam failure* (ANCOLD, 2000b)
- NRW *Guidelines for Failure Impact Assessment of Water Dams* (NR&M 2002b) (for the dam breach sizes and timings and the estimation of Population at Risk);
- ANCOLD *Guidelines on Risk Assessment* (ANCOLD, 2003) (with particular attention to the quantitative studies at advanced or very advanced levels).

A design life of no less than 150 years following the completion of any necessary dam safety upgrades is to be adopted when assessing the risk of failure over the life of the dam. Note that the probability of exceedence of an event over the design life is **not** simply the AEP times the life of the dam. It is calculated using the formula:

$$\text{Probability over design life} = 1 - (1\text{-AEP})^{\text{design life}}$$

The following steps are to be applied to the Risk Assessment Procedure:

1. Conduct a comprehensive, quantitative risk assessment study of the dam for all loads and consequences in accordance with the ANCOLD *Guidelines on Risk Assessment*, (ANCOLD 2003), and *Guidelines on Selection of Acceptable Flood Capacity for Dams*, (ANCOLD, 2000a). Details on the probability of flood events causing dam failure, based on the probability of the event over the life of dam and expected loss of life during these events must be reported in the Acceptable Flood Capacity assessment report. The following general qualifications apply:
   - As the potential for loss of life increases, the greater degree of rigour and thoroughness will be expected in the risk assessment.

- Dam is to be initially at Full Supply Level at the start of any flood events.[5]
- Breach dimensions and timing are determined in accordance with *Guidelines for Failure Impact Assessment of Water Dams* (NR&M, 2002b)
- Total PAR is estimated using the procedures contained in the NRW *Guidelines for Failure Impact Assessment of Water Dams* (NR&M, 2002b) or ANCOLD, *Guidelines on Assessment of the Consequences of Dam Failure* (ANCOLD, 2000b);
- *Graham's Method* (Graham, 1999) is to be used for estimating loss of life (LOL) due to dam break flood events. Unless it can be clearly demonstrated that warnings will be reliably issued and disseminated around the impacted community at least 12 hours prior to the anticipated impact of dam failure, it is to be assumed that no warning is available to the Population at Risk for dam failure events[6].
- Note that *Graham's Method* for estimating Loss of Life (LOL) during a dam break event is based on the total population at risk rather than the incremental population at risk produced by the *Guidelines for Failure Impact Assessment of Water Dams* (NR&M, 2002b). It is also significant that the 'flood severity' also tends to be greater with dam break. Unless it can be clearly demonstrated that fewer people will be exposed to any dam break flood discharge, the total PAR is to be used in assessments of potential loss of life due to the failure event. Thus the estimated incremental loss of life due to failure should be taken as:

$$\begin{matrix}\textit{Incremental LOL} \\ \textit{due to failure event}\end{matrix} = \begin{matrix}(\textit{LOL for flood event with dam failure}) \quad \textit{less} \\ (\textit{LOL for same event without dam failure})\end{matrix}$$

- Note that the LOL for flood events without dam failure is not covered by *Graham's Method* but is typically in the range 0.001xPAR to 0.0001xPAR. This means that the Incremental LOL can, in most circumstances, be taken as the total LOL due to dam break.

2. Use the risk assessment study data on the annual probabilities of dam failure and estimated LOL to determine whether the risk profile is within ANCOLD's recommended 'limits of tolerability'. These minimum limits of tolerability are reproduced below from the section on 'Life safety risks' in the ANCOLD *Guidelines on Risk Assessment* (ANCOLD, 2003):-
   - *for existing dams, an individual risk to the person or group, which is most at risk, that is higher than 10^{-4} per annum is unacceptable, except in exceptional circumstances*
   - *for new dams or major augmentations of existing dams, an individual risk to the person or group, which is most at risk, that is higher than 10^{-5} per annum is unacceptable, except in exceptional circumstances*
   - *for existing dams, a societal risk that is higher than the limit curve, shown on Fig. 7.4 [of ANCOLD, Guidelines on Risk Assessment] is unacceptable, except in exceptional circumstances*
   - *for new dams or major augmentations of existing dams, a societal risk that is higher than the limit curve, shown on Fig. 7.5 [of ANCOLD, Guidelines on Risk Assessment], is unacceptable, except in exceptional circumstances.*

[5] It is recognised that this restriction is conservative. However, anecdotal evidence suggests that there is a higher likelihood of large rainfall events occurring towards the end of a 'wet' wet season. The assumption of the dam initially at Full Supply Level is to apply unless dam owners can clearly demonstrate, to the satisfaction of the chief executive, that an alternative approach is appropriate.

[6] In making the case for a shorter warning time, the dam owner will need to demonstrate that a reliable warning will be able to be given under all reasonable circumstances that can be effectively and efficiently disseminated to the affected PAR and that suitable arrangements are in place to ensure that this will not reduce in effectiveness with the passage of time.

3. If the risk profile for the existing dam is above the limits of tolerability:
   (a) determine the storage inflow hydrograph for the critical duration design flood event commensurate with the AEP of the design flood event rainfall which just satisfies the limits of risk tolerability assuming the dam is in its current arrangement (Refer Section 3.5). As the Risk Assessment Procedure involves integration of all hazards including flood events, the risk analyst must be aware of the failure modes when evaluating the flood AEP, particularly where failure modes not directly associated with spillway flood discharge capacity are significant contributors to the risk i.e. piping;
   (b) formulate risk reduction options that would bring the risk profile down to the limit of tolerability.
4. Assess compliance with the ALARP principle by formulating additional risk reduction options that would bring the risk profile further below the limit of tolerability and undertaking a cost-benefit analysis for the upgrade options required to reduce the risk profile below the limits of tolerability based on:
   - incremental project costs and benefits to reduce the risk profile beyond the limits of tolerability. (Only include those costs considered necessary and sufficient to implement the measures to further reduce risk)
   - the cost-benefit methodology detailed in Appendix B;
   - a Value of a Statistical Life (VOSL) of $5 million (in 2004 dollars)[7].

   The options considered should be sufficient to clearly demonstrate that the ALARP criteria have been satisfied. In this context ALARP is considered to be satisfied whenever the incremental cost of undertaking a spillway upgrade project to reduce the risk below the specified limits of tolerability exceeds the benefits.
5. The spillway flood discharge capacity required to satisfy the limits of tolerability including ALARP is to be considered the Acceptable Flood Capacity (AFC).

   Note that in some circumstances where the flood risk is only a relatively minor part of the overall risk profile for the dam, other dam safety remedial works may be required to reduce the risk profile below the limits of tolerability.
6. Determine the relative proportion (as a percentage) of the inflow flood determined in Step 5 above that can be passed by the existing dam.

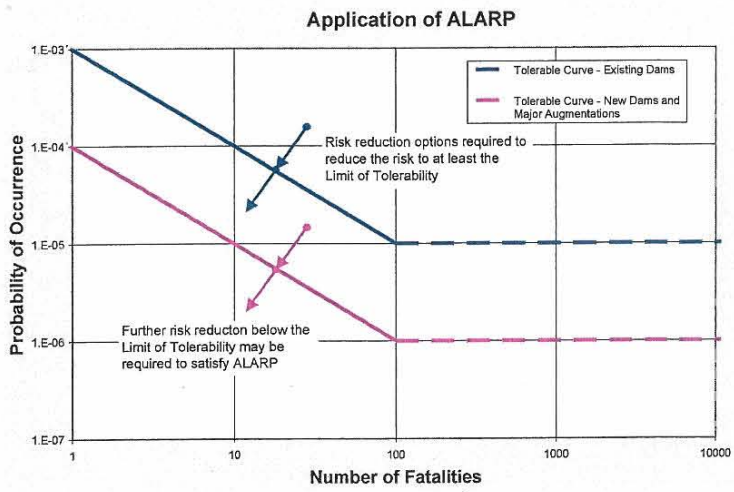


Figure 2 Application of ALARP to bring societal risk profile below Limit of Tolerability

[7] Note: Because of differences in the methodologies, the VOSL is not directly comparable with the ANCOLD Cost to Save a Statistical Life (CSSL)

3.5 Estimation of the critical duration storm event

The following process is generic for deriving the critical storm duration hydrograph and is to be used for estimating the critical duration inflow flood hydrographs for a given Annual Exceedence Probability (AEP) for all Acceptable Flood Capacity (AFC) assessment options.

(a) Determine the rainfall for a range of storm durations at the given AEP appropriate for the dam catchment and dam configuration. The required rainfall shall be estimated by applying, as appropriate:

- *CRC Forge method* (refer to the NR&M report *Extreme Rainfall Estimation Project (Hargraves, 2004)* for assessing probabilities for "rare" flood events (Note: flood probabilities are to be based on the probabilities of the causative rainfall events) and
- Appropriate methodology for assessing Probable Maximum Precipitation (PMP), in accordance with:
  - the Bureau of Meteorology (BoM) Bulletin 53 *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method* (GSDM, BoM, 2003a), or
  - the BoM *Revision of the Generalised Tropical Storm method for Estimating Probable Maximum Precipitation* (GTSMR, BoM 2003b).
- The provisions of *Australian Rainfall and Run-off* (AR&R 1999) shall be used for interpolating rainfall magnitudes between the CRC Forge rainfalls and the PMPs.

(b) The runoff from this rainfall is to be converted into inflow flood hydrographs using a non-linear run-off routing model (such as RORB, WBNM, RAFTS etc). Where reasonable calibration data is available, the model should be calibrated but with calibrations biased towards larger flows. Where reasonable calibration data is not available, the regional parameters approach presented in the Institution of *Engineers Australia, Book VI– Estimation of Large to Extreme Floods* (Nathan & Weinmann, 1999) should be applied.

All catchments are to be assumed in a saturated condition prior to the start of the storm event causing the rainfall. Unless the case for different loss models is appropriately made, *an "initial loss-continuing loss" model* is to be applied. Unless an effective case can be made to use other loss parameters, the initial loss/continuing loss parameters recommended in *Book VI of Australian Rainfall and Run-off – Volume 1* (AR&R 1999) are to be used.

When assessing the inflow hydrographs of flow into the dam reservoir during a flood event, all inflows into the storage should be considered. This should include any inflows from water harvesting pumps or run-off from catchments diverted into the storage. This will produce inflow hydrographs into the dam reservoir of the type shown in Figure 3.

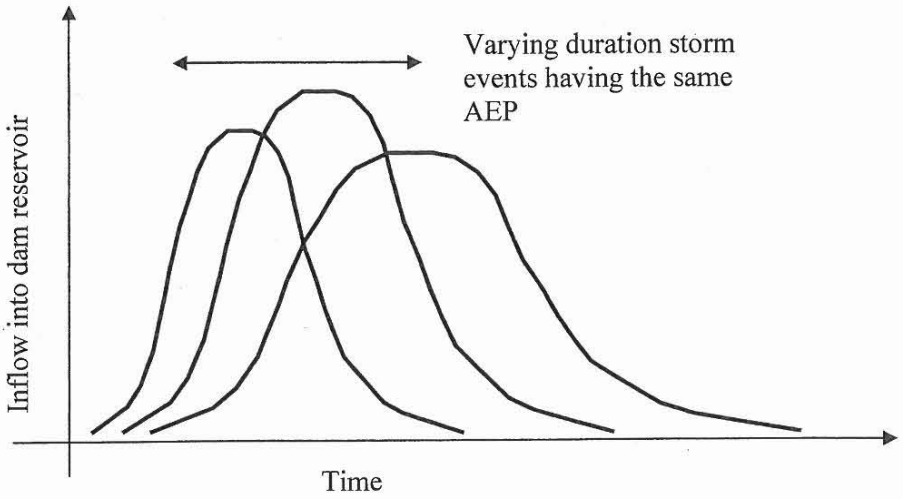


Figure 3 - Effect of storm durations on flood magnitude

(c) Route this run-off through the reservoir storage to determine the resultant maximum reservoir headwater and corresponding outflow from the dam storage for each flood event. Estimates of outflows during floods are to be based on the following assumptions:

- The reservoir is to be at Full Supply Level at the start of the flood event or sequence of flood events.
- Where the dam wall is designed to accommodate discharge over the non-overflow sections (e.g. as in some mass concrete dams), the analysis can take this discharge into account. However, if they are not designed to accommodate discharge (e.g. earth dam embankments), it is to be assumed that the existing spillway walls extend vertically upward to the height required to pass the discharge.
- When assessing the outflow for spillways controlled by spillway gates or other mechanical discharge control devices, the assumed reservoir operations are to be based on normal flood operational procedures for the dam together with:
  i. for assessments using the Fall-back option, the failure of at least 16 per cent of gates or other discharge devices (rounded up to the nearest whole number of gates) from the start of the event
  ii. for assessments using the Risk Assessment procedure the person doing the assessment should assess the probability of gate failure using the best available information.

(d) The result of steps (a) to (c) will be a series of 'Reservoir Level versus Time' curves as shown in Figure 4.

(e) Select the flood event producing the maximum reservoir level as the critical duration flood event for the dam.

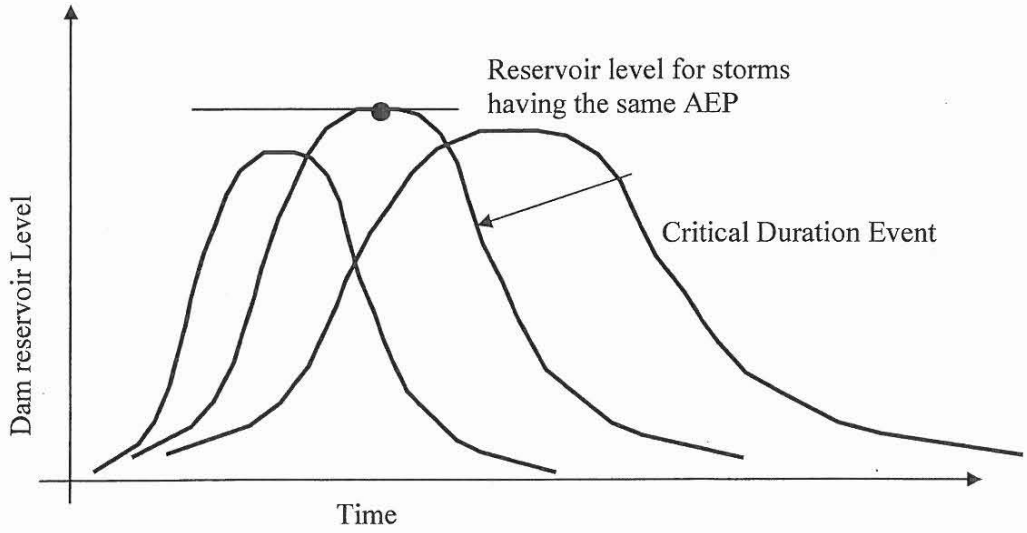


Figure 4 Selection of Critical Duration Flood Event

3.6 Freeboard

Freeboard should be provided above maximum flood levels for wind set-up and wave run-up. It should be noted that freeboard can be a significant component of any Acceptable Flood Capacity Assessment with considerations of the need for freeboard provisions being more critical for embankment dams, as such dams are generally more susceptible to breaching and failure by overtopping.

The magnitude of any necessary freeboard will vary for each dam and will depend on issues such as the :

- effective resistance to dam structure to waves and overtopping
- magnitude and direction of winds and the effective fetch for winds generated waves
- depth of the storage
- likely duration of headwater levels near the crest of the dam and the likely coincidence of these high flood levels with strong winds
- potential settlement of the crest of embankment dams.

The magnitude of wind set-up and wave run-up should be estimated using appropriate Australian wind data and the processes outlined in US Department of the Interior, Bureau of Reclamation, *Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams* (USBR 1981).

For proposed dams, it may be prudent to consider conservative freeboard provisions in view of:

- developments in meteorology and estimates of extreme rainfalls
- developments in hydrologic methodology and estimated floods
- the potential for future developments downstream requiring additional flood discharge capacity
- the generally low incremental cost of providing additional flood discharge capacity at the time of initial construction.

Concrete dams can sometimes tolerate the increased loading associated with some overtopping, and as such, may not require positive freeboard. Additionally, in some cases, concrete dams can accept a negative freeboard, which is some degree of overtopping. Items that need to be considered when assessing the required freeboard on concrete dams include the impact of the maximum reservoir headwater levels on the dam structure and the potential for scour of the toe of the dam or the abutments, which could affect stability.

For embankment dams, freeboard provision can alternatively be considered as an integral part of the risk assessment procedure.

Consideration may be given to minimal freeboard on submission of a well-supported risk analysis and having regard to:

- consideration of correlation between adverse winds and peak level in the reservoir due to the flood
- the duration and resistance to potential overtopping due to wind set-up and wave run-up and high headwater levels.

Provisions proposed for freeboard and the associated Acceptable Flood Capacity and relevant AEP shall be indicated in written Acceptable Flood Capacity Assessment reports produced in accordance with Appendix A.

4 Upgrade schedules

The required Acceptable Flood Capacity for a particular referable dam is the capacity required to safely discharge the Acceptable Flood Capacity as determined through risk assessment or other methods outlined in these guidelines and dam safety conditions and approved by the regulator. This capacity will be different for each dam and will depend on the individual circumstances of each dam. Dam owners should note that the required flood discharge capacity may change with time as changes to land use occur downstream of the dam.

All new referable dams will be required to provide a total discharge capacity equal to the Acceptable Flood Capacity from the time they become operational or start to permanently store water.

Owners of existing referable dams, which cannot safely discharge the Acceptable Flood Capacity, will be required to upgrade the spillway capacity of their dams. The timing of any necessary upgrade works for the dam is dependent on the proportion of the Acceptable Flood Capacity able to be safely passed by the existing dam. The timing will have to at least satisfy the schedule presented in Table 3.

The procedure to be adopted for determining the proportion of the Acceptable Flood Capacity able to be passed by the existing spillway(s) is as follows:

(a) The discharge values of the critical duration storm event inflow hydrograph are scaled by a factor 'k' to produce a 'trial' flood event such that

$$Q_{trial} = k\, Q_{cdse}$$

where Q_{trial} = The discharge ordinate of the trial flood event

Q_{cdse} = Inflow ordinate of the critical duration storm event producing the Acceptable Flood Capacity discharge

k = the proportion of the Acceptable Flood Capacity

The 'time base' for the trial inflow hydrograph remains unaltered.

(b) The resultant flood is then routed through the storage to determine the maximum headwater level in the reservoir.

(c) Steps (a) and (b) are repeated with new estimates of 'k' until

i. for cases where the Acceptable Flood Capacity is determined by the Small Dam Standard or the 'Fall-back option: Where the maximum headwater level in the storage just reaches the dam crest or some other level below the dam crest at which failure of the dam would be likely[8].

ii. for cases where the Acceptable Flood Capacity is determined by the Risk Assessment Procedure: Where the risk profile just satisfies the limits of tolerability and the ALARP criteria.

This proportion of the Acceptable Flood Capacity is taken to be the discharge capacity of the existing dam.

[8] Unless a dam embankment is specifically designed to be overtopped safely, the level at which failure is to be considered 'likely' is to be no higher than the level of the embankment crest. If defects are known to be present in embankment dams which could cause failure when the water level is below the level of the embankment crest, this lower level is to be taken as the 'maximum headwater level'. For dams assessed as being capable of being safely overtopped, this level of overtopping can be taken into account when determining 'maximum headwater level'. When considering the combined impact of wind set-up and waves on top of high reservoir levels due to flooding, the Annual Exceedence Probability of the overall event is to be the combined probability of the flood causing the headwater levels and the probability of the wind event generating the set-up and the waves. Wind set-up and wave heights are to be determined using appropriate Australian wind data and the processes contained in US Department of the Interior, Bureau of Reclamation, *Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams* (USBR, 1981).

Note that although consideration of the current consequences would be sufficient for this assessment, it is strongly recommended that likely future downstream developments be taken into account in assessing AFC.

The programming of any necessary dam safety upgrade works is to take into account, factors such as the time necessary to complete the work and the time of year available to undertake the work so as to minimise any additional risk to those living downstream.

Dam owners may choose to stage spillway upgrades to meet these timeframes, or to undertake all required works to meet 100 per cent of the required spillway capacity in one stage.

Tranche	Required minimum flood discharge capacity	Date by which the required minimum flood capacity is to be in place for existing dams
1	25% of AFC or 1:500 AEP flood event (whichever is the bigger flood)	These dams must be upgraded as soon as possible[1]
2	50% of AFC or 1:2000 AEP flood event (whichever is the bigger flood)	1 October 2015 [2,3]
3	75% of AFC	1 October 2025 [2,3]
4	100% of AFC	1 October 2035 [2,3]

Table 3: Schedule for Dam Safety Upgrades

Notes to Table

1. As a guide, it is expected that up to about five years may be required to complete a flood discharge capacity upgrade for dams greater than 10 meters in height, and two years will be required to complete a spillway upgrade for smaller dams. However, each case will be considered on its own merits.
2. In each case the required discharge capacity will need to be reassessed just prior to the undertaking of final spillway upgrade works to ensure that the required Acceptable Flood Capacity has not changed and that the planned spillway capacity is still consistent with the specified upgrade program.
3. The timing of the tranches 2, 3 and 4 will be confirmed once the Acceptable Flood Capacity, and related, assessments have been completed for all or most of the known referable dams. This is anticipated to occur by 1 July 2008.

5 Glossary

Please note: This is a selected glossary only. Please refer to the Glossary in the various ANCOLD Guidelines for a more comprehensive definition of all terms.

AEP - Annual Exceedance Probability – The probability that a particular flood value will be exceeded in any one year.

AFC - Acceptable Flood Capacity - The overall flood discharge capacity required of a dam determined in accordance with these guidelines including freeboard as relevant, which is required to pass the critical duration storm event without causing failure of the dam.

ALARP – As Low As Reasonably Practicable principle, which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate (depending on the level of risk) to the improvement gained.

ANCOLD - Australian National Committee on Large Dams

AR&R 99 – In the context of this paper it refers to 'Australian Rainfall and Runoff, A guide to Flood Estimation, Book VI, Estimation of Large to Extreme Floods', 1999.

BoM – Commonwealth Bureau of Meteorology

CRCForge – Co-operative Research Centre Focussed Rainfall Growth Estimation – A regional frequency analysis technique used to derive estimates of large to rare rainfall (see Section 3.5).

Critical Duration Design Flood Event – The design flood event having a duration which causes the maximum discharge from a dam for a given Annual Exceedence Probability.

DCF - Dam Crest Flood – the flood event which, when routed through the storage with the storage initially at Full Supply Level, results in still water in the storage, excluding wind and wave effects which:

- for an embankment dam, is the lowest point of the embankment crest,
- for a concrete dam, is the level of the non-overflow section of the dam, excluding handrails and parapets if they do not store water against them;
- for a concrete faced rockfill dam, is the lowest point of the crest structure or a point on a wave wall if it is designed to take the corresponding water load.

Dam Break Flood – The flood event occurring as a consequence of dam failure.

Dam failure is the physical collapse of all or part of a dam or the uncontrolled release of any of its contents.

Design Life – The useful life for which a structure is designed.

EAP – Emergency Action Plan (prepared and implemented in accordance with requirements of *Queensland Dam Safety Management Guidelines* (NR&M, 2002a)

Failure Mode – A way that failure can occur, described by a means by which element or component failures must occur to cause loss of the sub-system or system function.

Fall-back option – is the assessment methodology described in Section 3.2 of these guidelines.

Fatality rate - is the appropriate fatality rate in Graham's loss of life formula (Graham, 1999).

FIA - Failure Impact Assessment undertaken and certified in accordance with the requirements of the Water Act 2000 and NR&M's *Guidelines for Failure Impact Assessment of Water Dams* (NR&M 2002b).

Flood Discharge Capacity – The capacity to discharge floods (in m^3/sec)

Freeboard – The vertical distance between a stated water level and the top of the non-overflow section of a dam. The part of the freeboard that relates to the flood surcharge is sometimes referred to as the "wet freeboard", and that above the flood surcharge, due to wind and other effects, is sometimes referred to as the "dry freeboard".

FSL – Full Supply Level – The level of the water surface when the water storage is at maximum operating level, when not affected by flood.

Fuse plugs (and fuse gates) – Discharge elements designed to fail in a controlled fashion once a design event has been triggered (see Section 3.1).

Graham's Method – A method for estimating the loss of life due to dam failure (refer to Section 3.4)

Height (of dam) – means the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the dam or, if the dam is not across a watercourse, between the lowest elevation of the outside limit of the dam and the top of the dam.

Hydrograph - A graphical representation of a time-discharge curve of the unsteady flow of water.

Hazard Category – The potential incremental losses and damages directly attributable to the failure of the dam.

Incremental PAR – refer to PAR.

Limits of Tolerability – A risk that society can tolerate so as to secure certain net benefits (refer to Section 3.4)

LOL - Loss of Life - means the estimated loss of life in the event of a dam failure.

NRW – The Queensland Department of Natural Resources & Water (previously known as the Department of Natural Resources & Mines or NR&M or the Department of Natural Resources, Mines and Water or NRMW.

Outlet Works – A combination of structures and equipment required for the safe operation and control of water released from a reservoir to serve various purposes, e.g. regulate stream flow and quality; provide irrigation, municipal, and/or industrial water.

PAR - Population at Risk – means the number of persons, calculated under the guidelines referred to in s.482 (I) (b) [of the Water Act 2000], whose safety will be at risk if the dam, or the proposed dam after its construction, fails. Unless otherwise indicated, PAR is the 'incremental PAR' due to the failure event i.e. the difference in the PAR for the same event with dam failure relative to the event without dam failure. When 'Total PAR' is referred to, this is the total PAR inundated both due to the natural flood event and the natural flood levels aggravated by the failure event.

PMP Design Flood – The flood resulting from the PMP using AEP neutral assumptions of catchment conditions.

PMF - Probable Maximum Flood – The flood resulting from PMP, and where applicable snow melt, coupled with the worst flood-producing catchment conditions that can be realistically expected in the prevailing meteorological conditions.

PMP - Probable Maximum Precipitation – The theoretical greatest depth of precipitation for a given duration that is physically possible over a particular catchment area, based on generalised methods.

Probability of Occurrence – The probability that the risk (event) will occur.

Referable Dam – A dam, or a proposed dam for which:

(a) a failure impact assessment is required to be carried out [under the Water Act 2000]; and

(b) the assessment states the dam has, or the proposed dam after its construction will have, a category 1 or category 2 failure impact rating; and

(c) the chief executive has, under section 487 [of the Water Act 2000], accepted the assessment.

The following are not referable dams:

(a) a dam containing, or a proposed dam that after its construction will contain, hazardous waste.

(b) a weir, unless the weir has a variable flow control structure on the crest of the weir.

The following are not dams and cannot therefore be referable dams:

(a) a rainwater tank;

(b) a water tank constructed of steel or concrete or a combination of steel and concrete;

(c) a water tank constructed of fibreglass, plastic or similar material.

Ring tank – A dam that has a catchment area that is less than 3 times its maximum surface area at full supply level.

Risk Assessment Procedure – is the assessment methodology described in Section 3.4 of these guidelines.

Risk Profile - The aggregated relationship between the consequences resulting from a range of adverse events and their probability of occurrence (see Section 3.4).

RPEQ – A Registered Professional Engineer of Queensland as defined under the Queensland Professional Engineers Act 2002.

Small Dams Standard – is the assessment methodology described in Section 3.2 of these guidelines.

Societal Discount Rate – The discount rate used in determining the net present value (refer to Appendix B)

Societal Risk – The risk of widespread or large scale detriment and multiple loss of life from the realisation of a defined hazard. Refer also to the definition in ANCOLD *Guidelines on Risk Assessment* (ANCOLD, 2003)

Spillway – A weir, channel, conduit, tunnel, gate or other structure, designed to permit discharges from the reservoir when pondage levels rise above FSL; can include secondary, auxiliary, emergency spillways or fuse plugs.

Spillway Design Flood – The flood event which can be routed through the dam (with appropriate allowance for freeboard due to wind and wave effects) without any damage to individual sections of the dam.

Sunny Day Failure - means a dam failure which is not significantly affected by a natural flood occurring at the same time.

VOSL - Value of Statistical Life

Weir - A barrier constructed across a watercourse below the banks of the watercourse that hinders or obstructs the flow of water in the watercourse.

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Appendix A - Summary of Written Acceptable Flood Capacity Assessment Requirements

Summary of Written Acceptable Flood Capacity Assessment Requirements

The Acceptable Flood Capacity Assessment must be certified by a registered professional engineer as accurate and reasonable. The following information must be included in a written Acceptable Flood Capacity Assessment report:

Executive Summary/Introduction

A general description of the dam and the result of the Acceptable Flood Capacity Assessment including:

- Name of dam;
- Location of dam (i.e. longitude and latitude);
- Real property description of the land on which the dam structure is located
- Photographs of the existing dam or dam site
- Name of the owner of dam (i.e. name of individual or company).
- Dam owner contact details (i.e. postal address, street address, phone number, facsimile, email);
- Status of dam (i.e. existing or proposed dam or proposed work);
- Date dam construction completed to current arrangement;
- Development permit and water licence details (if any);
- Date last failure impact assessment accepted by the chief executive;
- The maximum population at risk;
- The failure impact assessment category for the dam;
- Type of dam (i.e. homogenous earthfill dam, zoned earth and rockfill dam, concrete dam or other);
- Height and storage capacity of the dam;
- Dam capacity to Full Supply Level (in megalitres);
- Spillway description (Type & Dimensions);
- Spillway discharge rating curves and any applicable operational rules (for gated operations) used in determining the AFC;
- Existing Flood Discharge Capacity for the dam at the dam crest level or a level with the design freeboard;
- AEP of the Existing Flood Discharge Capacity
- Acceptable Flood Capacity (AFC) for the dam;
- Spillway Design Flood and, if it is less than the AFC, details as to how it was assessed and the impacts of floods in excess of the Spillway Design Flood;
- Identified current flood discharge capacity as a percentage of AFC.

Data and methodology used

The Acceptable Flood Capacity Assessment shall include a summary of the data on which the assessment is based and the details of the methodology used (small dams standard/ fallback option /risk assessment) including, but not limited to the following:

Risk assessment	Small Dams Standard/Fallback Option
• Description of methodology for determining design rainfalls and results; • Description of methodology for determining spillway capacity floods and the results of routing the floods through the storage; • Description of methodology for assessing consequences of failure • Basis of the risk assessment process, methodology, parameter values and uncertainties including documentation as to: o Demonstrate the appropriateness of the assessment; o How the risks were identified and assessed; o What systems are applied to ensure the risks are properly controlled?	• Description of methodology for determining design rainfalls and consequent flood magnitudes; • Details of the operating procedures adopted in determining the AFC; • Details of consequences of dam failure for Sunny Day and Flood failure conditions • PAR for each failure case considered; • Interpolations.

Details of the review of the appropriateness and accuracy of the data (including the details of dam break analyses for "Fallback Option") must be also included in the assessment.

Note that although consideration of the current consequences would be sufficient for this assessment, it is strongly recommended that all likely future downstream developments be taken into account in assessing AFC.

Assessment

Details of the assessment including, but not limited to the following:

Existing Dams	Proposed dams
• Dam Crest Flood (DCF) for the existing arrangement, with the assigned Annual Exceedance Probability (AEP), to ANCOLD *Guidelines on Selection of Acceptable Flood Capacity for Dams,* Appendix 1. • For dams with hazard category of *Extreme* or *High A*, PMF, based on Book VI, ARR (Nathan & Weinmann, 1999) procedures, with FSL the pre-flood reservoir condition, and including information on the assigned values for all influencing parameters such as temporal and spatial patterns and losses. • For dams with hazard category of *High B* or *High C*, 'PMP Design flood' based on Book VI procedures with the reservoir at FSL at the start of the flood event or sequence of flood events. • The assessed hazard category, and potential consequences, noting any changes to potential consequences since the previous review report-both total and incremental consequences are to be reported including the potential for loss of life. • Assessment of the allowance for freeboard with reasons • Note of any changes to dam management, operating rules, conditions and surveillance procedures since the previous review report. • Information on EAPs in place. • Identified hydrologic deficiencies including assessment against Guideline criteria • Estimated risks of failure and assessment of their tolerability. • Capacity to accommodate future climate change (i.e. what is in reserve?)	• Assessed hazard category and consequences – total and incremental - are to be reported including the potential for loss of life. • Hydrologic assessment against deterministic criteria. (needs further definition) • DCF and PMF and/or PMP Design flood, as for review of existing dams, and appropriate. • Proposals for freeboard provisions with reasons for the nominated freeboard. • Proposals, including assessed risks, for flood management during construction • Proposed dam management operating rules, conditions and surveillance procedures. • Provisions, if any, for future climate change.

Risk reduction proposals for existing dams (following the completion of an assessment for the dam)

Risk reduction measures only need to be considered as part of the risk assessment process when considering whether ALARP has been satisfied.

- Risk reduction options considered and comparative assessments against existing arrangement.
- Proposed DCF, PMF and/or PMP Design Flood, with assigned AEP, as appropriate for each of the options considered.
- Assessed hazard category and potential dam failure consequences, after implementation of risk reduction measures.
- Details of any structural measures to be relied on for risk reduction including changes to spillways or dam embankments etc.
- Details of any proposed non-structural measures to be relied on for risk reduction including changes to dam management, operating rules and flood warning systems, conditions and surveillance procedures.
- Proposed freeboard provisions and basis for these for each of the options considered.
- Proposals, including assessed risks, for flood management and construction management during construction.
- Interim EAPs, both during planning and during construction.

Registered Professional Engineer details.

The Acceptable Flood Capacity Assessment is to incorporate a certification from a Registered Professional Engineer (RPEQ). This certification shall include:

- Name of the certifying RPEQ.
- Registration number.
- Contact details (including postal address, street address, telephone number, facsimile, email as appropriate).
- A statement that this AFC assessment is reasonable and accurate and has been done in accordance with the NRW Guidelines on Acceptable Flood Capacity for Dams;
- Signature of RPEQ.
- Date.

Appendix B - Methodology for Demonstrating Compliance with ALARP.

Methodology for demonstrating compliance with ALARP.

The **ALARP principle** requires that risks should be 'as low as reasonably practicable'. The methodology for demonstrating risks are ALARP is to be applied to all assessments where the "risk assessment procedure" is used for determining Acceptable Flood Capacity.

This requirement is to reduce risks to life to the point where further risk reduction is impracticable or requires action that is grossly disproportionate in time, cost, trouble and effort to the reduction in risk achieved. This principle forms the balance between equity and efficiency, with the balance deliberately skewed in favour of equity.

To decide whether risks are ALARP, it is necessary to consider the possibilities for further risk reduction beyond the limits of tolerability and their relative ease or difficulty (the sacrifice) of implementing them and to balance these against the benefits of implementing them. To demonstrate this, for the purposes of these guidelines, it is necessary to formulate risk reduction options and to prepare concepts and realistic cost estimates to undertake the risk reduction measures.

Each case will depend on the circumstances of the dam under consideration, but further risk reduction measures considered should not only include major modifications to the dam structure but should also include modifications or additions of individual pieces of equipment and/or components of individual structures where such measures are likely to have a significant impact on the overall risk of dam failure. In assessing the costs of these further risk reduction measures, only the incremental costs associated with risk reductions beyond the limit of tolerability should be considered[9].

By undertaking the activities detailed in these guidelines and incorporating the outcomes in their decision recommendations, the analysts can assist the decision-maker, who has to make the final judgement that risks are ALARP.

A particular owner's ability or inability to afford a risk reduction measure – that is, the owner's financial circumstances - is not a consideration in deciding whether life safety risks are ALARP.

The methodology outlined below presents a cost-benefit framework for determining whether the ALARP upgrade improvements are required. This methodology assumes that a number of engineering calculations have already been performed to determine the probability of a flood event or other hazard (e.g. seismic, wind, piping) causing dam failure based on the probability of the event over the life of the dam and the expected loss of life during the event. The answers to these calculations are then applied to the methodology presented below.

A range of potential ALARP spillway capacity upgrades (including any necessary structural upgrades to accommodate additional headwaters and flows) should be considered in the assessment. The levels of these upgrades must then be used to develop a cost benefit curve for the spillway upgrade options, so that the point at which costs equal benefits can be identified. This optimal ALARP upgrade standard should then be compared with and plotted on the same graph as the limit of tolerability to demonstrate the upgrade point with which dam owners are required to comply.

The methodology requires the probable loss of life due to dam failure[10] and probable property damage over the life of the dam due to dam failure to be determined, for both the project that just satisfies the tolerable risk criteria without consideration of ALARP[11] and a range of further potential ALARP spillway upgrades.

The probability of loss of life due to dam failure over the dam's life is calculated by examining the

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[9] Where the overall dam upgrade project is to proceed as one overall project, the project costs associated with an ALARP component of the project should only include that proportion of the overall establishment costs associated with the upgrade of the works beyond the 'tolerable limit'.

[10] Note that probability of expected loss of life due to dam failure over the life of the dam may also be expressed as the probability of death and dam failure occurring at the same time.

[11] The minimum tolerable spillway standard prior to the consideration of ALARP is the spillway capacity which just allows the risk profile to meet the limit of tolerability criteria.

population at risk, the fatality rate[12] and the probability of dam failure during a flood event (or the flood event plus a proportional increase in discharge capacity equal to the level of ALARP upgrade being examined) over the nominated design life of the dam[13] for the particular catchment. The probability of expected loss of property due to dam failure over the dam's life is calculated by examining the property at risk, the expected damage during a flood event and the probability of dam failure during that flood event (or the flood event plus a proportional increase in discharge capacity equal to the level of ALARP upgrade being examined).

The first calculation in the methodology should be applied to the dam arrangement that just satisfies the tolerable risk criteria without consideration of ALARP, as follows:

$$E(LOL_{dam\ life}) = [\Sigma (F_i \times PAR_i)] \times P(FE)$$

which simplifies to:

$$E(LOL_{dam\ life}) = E(LOL) \times P(FE)$$

Where:

$E(LOL_{dam\ life})$ = total expected LOL over the life of the dam.
$E(LOL)$ = expected total LOL during a failure event;
F_i = fatality rate for each separate community,(i), in the particular catchment (This rate should be calculated for each community as some communities may be subject to different levels of flood severity and different flood vulnerabilities);
PAR_i = total PAR in each separate community during the failure event corresponding to the fatality rate F_i in the particular catchment;
$P(FE)$ = probability of dam failure during a flood, seismic or other event over the life of the dam;

The calculation is also applied separately to the proposed ALARP upgrade standard. That is:

$$E(LOL_{dam\ life})^* = [\Sigma (F_i^* \times PAR_i^*)] \times P(FE)^*$$

which simplifies to:

$$E(LOL_{dam\ life})^* = E(LOL)^* \times P(FE)^*$$

Where:

$E(LOL_{dam\ life})^*$ = total expected LOL over the life of the ALARP upgraded dam.
$E(LOL)^*$ = expected total LOL during a failure event at the ALARP upgraded dam;
F_i^* = fatality rate at ALARP upgraded dam for each separate community, (i), in the particular catchment (note that this is necessary as some individual communities comprising the PAR may be subject to different levels of flood severity and different flood vulnerabilities);
PAR_i^* = total PAR in each separate community during the failure event corresponding to the fatality rate F_i^* in the particular catchment;
$P(FE)^*$ = probability of dam failure due to a nominated flood, seismic or other event greater than the minimum tolerable spillway standard over the life of the ALARP enhanced dam;

Once the expected loss of life is determined based on a dam complying with the tolerable risk level and the various levels of ALARP upgrade, the incremental reduction in the probability of loss of life from dam failure as a result of the ALARP upgrade being performed may be calculated. This requires the difference in the total expected loss of life calculated in the first step to be calculated, as follows:

$$E(LOL_{dam\ life})_{Incremental} = E(LOL_{dam\ life}) - E(LOL_{dam\ life})^*$$

Where:

$E(LOL_{dam\ life})_{Incremental}$ = incremental reduction in total expected LOL over the life of the dam due to the ALARP upgrade being performed

[12] The 'fatality rate' is the appropriate fatality rate in Graham's loss of life formula (Graham, 1999) assuming 'no warning time' unless a strong case to the contrary is made.
[13] To be taken as 150 years from the completion of the spillway upgrade.

Similarly, the expected property damage can be considered by determining the incremental flood damage due to the failure of the dam during an event and the changes to the operations and maintenance costs due to the upgrade.

$$E(Damages_{dam\ life})_{Incremental} = E(Damages_{dam\ life}) - E(Damages_{dam\ life})^*$$

Where:

$E(Damages_{dam\ life})_{Incremental}$ = Incremental damages due to the dam failure event

$E(Damages_{dam\ life})$ = the expected total damages resulting from the event without dam failure

$E(Damages_{dam\ life})^*$ = the expected total damages resulting from the event with dam failure

The expected damages are to be based on the NRW *Guidance on the Assessment of Tangible Flood Damages* (NR&M 2002c).

This incremental reduction in the estimated loss of life over the life of the dam, attributable to the ALARP upgrade being performed is then used to determine the expected total benefit ($E(TB_t)$) resulting from the ALARP upgrade. This is done by multiplying the VOSL by the incremental reduction in the estimated over the life of the dam due to the ALARP upgrade being performed, as shown below.

$$E(TB_t) = E(LOL_{dam\ life})_{Incremental} \times VOSL$$

It is presumed that the expected total benefit will be achieved in the year the upgrade is completed (ie, time = t). This is the case as the reduction in the probability of dam failure as a result of an increase in the level of AEP flood event that the upgraded dam can endure, will occur in the year that the upgrade work is completed. This benefit is not accrued in prior or subsequent years, as the timing of the total benefit is taken to align with the reduction in risk and the completion of work.

A societal discount rate of 6%, as noted in Queensland Treasury Guidelines (Qld Treasury, 2000 and Qld Treasury 1997) is to be adopted when determining the net present value of cash flows. The expected total cost of the upgrade should also be ascertained in current year dollars using the same societal discount rate. This will necessarily require the dam owner to consider the timing of cash flows associated with the upgrade and apply a similar 6% discount rate. The discounting calculations are presented below.

$$E(TB_0) = E(B_t) / (1+r)^t$$

and

$$E(TC_0) = [E(C_t) / (1+r)^t] + [E(C_{t-1}) / (1+r)^{t-1}] + [E(C_{t-2}) / (1+r)^{t-2}] + \ldots + [E(C_{t-n}) / (1+r)^{t-n}]$$

Where:

r = societal discount rate
t = the time period in which the benefit will be received and the costs will be incurred
$E(TB_0)$ = expected total benefit in current year dollars
$E(TC_0)$ = expected total cost in current year dollars

These expected total benefits and costs may then be compared to establish if the ALARP upgrade is likely to produce total benefits in excess of total costs (ie, a cost benefit ratio of less than unity). If the net benefit is positive then the project should go ahead. The cost- benefit decision calculation is presented below:

If: $E(TC_0) / E(TB_0) \leq 1 \rightarrow$ ALARP spillway upgrade required
$E(TC_0) / E(TB_0) > 1 \rightarrow$ ALARP spillway upgrade not required

This calculation illustrates that where the analysis produces a cost to benefit ratio of less than or equal to one (ie, benefits at least match the costs), then the ALARP upgrade would be required. An example of how this methodology should be applied appears in the example presented below.

Through this process, the cost benefit curve can be plotted so that the appropriate level of dam upgrade may be identified.

From a social economic perspective, the appropriate level of upgrade beyond the limit of tolerability would be where the marginal benefits of the total spillway upgrade equal the marginal costs of the total spillway upgrade. This is the point at which total net benefits are maximised. This point may be determined by graphing the cost benefit curve, of total expected benefits against the relative increase in flood discharge capacity based on the calculations performed for the range of ALARP spillway upgrades.

When relying on 'risk assessment', dam owners are required to undertake upgrades at least to the 'tolerable risk' line. The extent to which the spillway needs to be further upgraded depends on whether the point at which the total benefits equal the total costs lies beyond the limit of tolerability or not.

ALARP upgrade options to be considered

There are a wide range of potential upgrade options to be considered as part of the upgrade process to reduce the risks below the tolerable risk level. Such options that might be considered include (but may not be limited to):

- Widening or deepening an existing spillway
- The addition of spillway gates or some other flow control structure
- Modifying the operating systems/rules for the structure so that risk of failure is reduced
- Structural modifications to the dam to enable it to safely pass overtopping flows
- Additions/modifications to dam embankments and foundations to reduce the risk of failure
- The addition of additional spillways such as higher level auxiliary spillways or fuse plug spillways
- Raising or modifying non-overflow dam sections to reduce the risk of failure
- Diversion of some of the catchment around the dam
- A combination of any or all of the above.

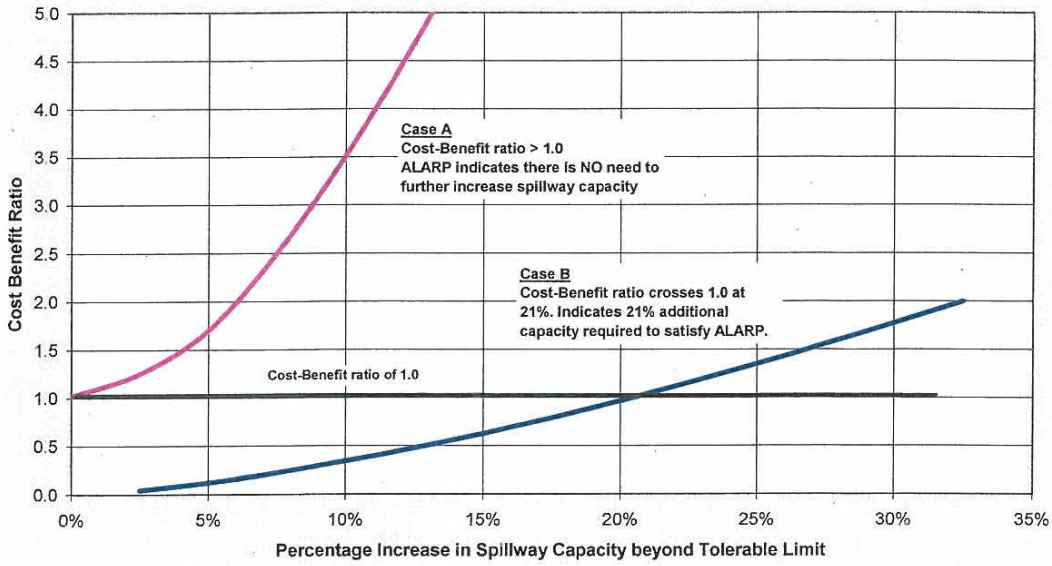
The required accuracy of the necessary estimates for these options will be dependent on the sensitivity of the outcome. The accuracy need not be high where the result is clear-cut one way or the other.

The actual ALARP upgrade options to be considered in each particular case will be dependent on the circumstances at each individual dam and advice may need to be sought from an RPEQ experienced in dam engineering. Non-structural options can only be considered if it can be clearly demonstrated that such options can be relied on in the long term and are under some degree of control by the dam owner.

Example

An example of the ALARP methodology is provided below to illustrate the practical application of calculating the life benefits achieved by upgrading the size/capacity of a spillway by 10% beyond the limit of tolerability standard. The assumptions made below are presumed to have been provided through engineering studies and calculations

Figure B1 - Example of Demonstrating Compliance with ALARP



Assumptions:

$P(FE)$ = 0.04878 (= probability of a 1 in 3000 year AEP event occurring over a 150 year life of the dam)

$P(FE)^*$ = 0.02107 (= probability of a 1 in 7045 year AEP event [equivalent to a 10% increase in spillway capacity] occurring over a 150 year life of a dam

F = 0.15 (for medium severity flooding where houses would be damaged during flood events)

PAR = 10 (obtained from Failure Impact Assessment studies)

$VOSL$ = \$5m AUD (2004 dollars)[14]

r = 6%

t = 5 (ie, upgrade will be completed in year 5)

$E(TC)$ = \$250,000 (ie, expected total cost of ALARP upgrade over five years as follows: year 1: 5%; year 2: 5%; year 3: 15%; year 4: 35%; year 5: 40%)

Probability of death given dam failure

Under tolerable safety standard

$$E(LOL_{dam\ life}) = [(F_i \times PAR_i) + (F_k \times PAR_k) + (F_m \times PAR_m)] \times P(FE)$$
$$= [0.15 \times 10] \times 0.04878 = 0.07317$$

After ALARP spillway improvement

$$E(LOL_{dam\ life})^* = [(F_i^* \times PAR_i) + (F_k^* \times PAR_k) + (F_m^* \times PAR_m)] \times P(FE)^*$$
$$= [0.15 \times 10] \times 0.02107 = 0.03160$$

[14] Assumed based on a figure within the strong to very strong ANCOLD justification range for risks just above the broadly acceptable risk.

Incremental reduction in probability of death given dam failure

$$\text{Incremental } E(LOL_{\text{dam life}}) = E(LOL_{\text{dam life}}) - E(LOL_{\text{dam life}})^*$$
$$= 0.07317 - 0.03160 = 0.04157$$

Expected Benefit of ALARP spillway upgrade

In year 5:

$$E(B_t) = \text{Incremental } E(LOL_{\text{dam life}}) \times VOSL$$
$$E(B_5) = 0.04157 \times \$5{,}000{,}000 = \$207{,}850$$

At time zero:

$$E(B_0) = E(B_t) / (1+r)^t = \$207{,}850 / 1.06^5 = \$155{,}990$$

Expected indexed Cost of ALARP spillway upgrade at time zero

$$E(C_0) = [E(C_t) / (1+r)^t] + [E(C_{t-1}) / (1+r)^{t-1}] + [E(C_{t-2}) / (1+r)^{t-2}] + \ldots + [E(C_{t-n}) / (1+r)^{t-n}]$$
$$= \$100{,}000 / 1.06^5 + \$87{,}500/1.06^4 + \$37{,}500/1.06^3 + \$12{,}500/1.06^2 + \$12{,}500/1.06$$
$$= \$198{,}500$$

Cost-Benefit Analysis

$$E(C_0) / E(B_0) = \$198{,}500 / \$155{,}900 = 1.27$$

In this example, for this potential project, as the costs of undertaking the additional upgrade outweigh the benefits, the dam owner would not be required to increase the minimum safety of the spillway by 10% above the tolerable limit to sustain a larger AEP flood event. Had the benefits outweighed the costs however, the upgrade would have been required.

Such cost -benefit assessments should be undertaken for a range of upgrades beyond the limit of tolerability, so that the optimal level of ALARP upgrade could be identified. If this was done and a cost-benefit curve of the type shown in the Figure B1 for 'Project Type A' might result.

To achieve compliance with the minimum safety standard, dam owners are required to undertake upgrades until the optimal upgrade point is reached (being the point at which benefits equal costs). Thus, for the Project Type A example, where no point is below a Cost-Benefit ratio of 1.0, no further upgrade would be required to satisfy ALARP. However, if a cost-benefit curve like 'Project Type B' resulted, a additional 21% upgrade would be required in order to satisfy ALARP.

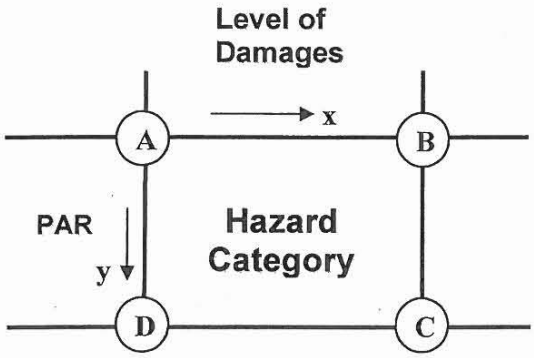
Appendix C - Methodology for Interpolating Required AEP within a particular Hazard Category using Fallback Procedure

Methodology for Interpolating Required AEP within a particular Hazard Category using Fallback Procedure

The following methodology can be applied for interpolating the required AEP of the Acceptable Flood Capacity within a specific Hazard Category for the Fallback procedure.

The following interpolation procedure is to be applied within any 'Severity of Damage and Loss' and 'Population at Risk' cell of Table 2:

(a) Once the consequences of failure (level of damage) and the PAR have been assessed using the provisions of Section 3.3, determine the appropriate Hazard Category and determine the Annual Exceedence Probabilities (AEPs) to be applied at each of the points A, B, C and D using the AEPs set out in Table 2. (Note the points A, B, C and D are not to be confused with the hazard category in Table 2)



(b) Determine the 'x' and 'y' coordinates for the most critical failure case.
x = the relative severity of damage and loss relative to the boundaries of the damage scale
y = the log of the PAR

Where 'x' and 'y' are calculated as follows:

$x = [\log_{10}(\text{Damage}) - \log_{10}(\text{Damage @ A})]/[\log_{10}(\text{Damage @ B}) - \log_{10}(\text{Damaged @ A})]$

$y = \log_{10}(\text{PAR}/10)$

Where the values of damages at A/D and B/C have been interpolated from the ranges of damages contained in ANCOLD 2000b for:

1. Estimated Costs
2. Service and Business relating to the Dam
3. Social
4. Natural Environment

With the lowest AEP selected corresponding to the worst combination of 'x' and 'y' values being adopted.

Note for 'Major' levels of damage, the maximum value of the 'x' coordinate shall be taken to correspond to twice the level of damages at the boundary between 'medium' and 'major'.

(c) Using the following relationship, determine for each combination of 'PAR' and 'Level of Damages' the required AEP of the design flood and select the smallest AEP as the required AEP of the AFC.

$$\text{Log(AEP)} = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy$$

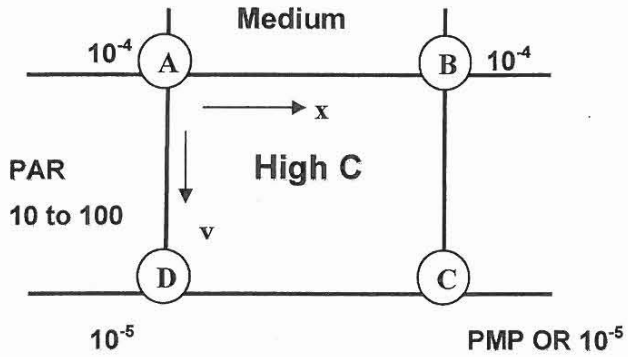
Where

α_1 = the log (AEP) of the design flood at point A
α_2 = the log (AEP) of design flood at point B – α_1
α_3 = the log (AEP) of design flood at point D – α_1
α_4 = the log (AEP) of design flood at point C – α_1 – α_2 – α_3

By way of example for the case of

- a PAR of 29 and serious damage or destruction of 10 houses producing a 'Medium' level of residential damages[15].
- A catchment area of less than 100km^2

Because the catchment area is less than 100 km^2, Table 2 indicates the notional AEP of the Probable Maximum Precipitation is 1.0x10-7 and the Hazard Category is 'High C'.



Point 'A' corresponds to a PAR of 10 and, from Appendix D of ANCOLD *Guidelines on Assessment of Consequences of Dam Failure* (ANCOLD, 2000b), a level of damages equivalent to the destruction of four houses.

Point 'B' corresponds to a PAR of 10 and a level of damages equivalent to the destruction of forty-nine houses.

Point 'C' corresponds to a PAR of 100 and a level of damages equivalent to the destruction of forty-nine houses.

Point 'D' corresponds to a PAR of 100 and a level of damages equivalent to the destruction of four houses.

From Table 2 of this Guideline, the AEP of the AFC at point 'A' and 'B' is 1.0x10-4 and the AEP of the AFC at points 'C' and 'D' is the probability of the PMP or 1.0x10-5 (whichever is greater) i.e 1.0x10-5.

Thus ...

At point A $y = \log(10) = 1$, $x = 0$, required AEP = $1.0x10^{-4}$
At point B $y = \log(10) = 1$, $x = 1$, required AEP = $1.0x10^{-4}$
At point C $y = \log(100) = 2$, $x = 1$, required AEP = $1.0x10^{-5}$
At point D $y = \log(100) = 2$, $x = 0$, required AEP = $1.0x10^{-5}$

At the point of interest $x = (\log 10 - \log 4)/(\log 49 - \log 4) = 0.366$

$$y = \log_{10}(29/10) = 0.4624$$

$$\alpha_1 = \log_{10}(1.0x10^{-4}) = -4$$

[15] Under the ANCOLD Guidelines on the Assessment of Consequences of Dam failure (ANCOLD 2000b) a 'Medium' level of residential damages corresponds to 'Destroy 4 to 49 houses or damage to a number'.

$$\alpha_2 = \log_{10}(1.0\text{x}10^{-4}) - \alpha_1 = -4 - (-4) = 0$$

$$\alpha_3 = \log_{10}(1.0\text{x}10^{-4}) - \alpha_1 = -5 - (-4) = -1$$

$$\alpha_4 = \log_{10}(1.0\text{x}10^{-5}) - \alpha_1 - \alpha_2 - \alpha_3 = -5 - (-4) - (-1) - 0 = 0$$

Which gives a required AEP of the Acceptable Flood Capacity of

$$\text{Log(AEP)} = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy$$

$$= -4 + 0 * x - 1 y + 0 * x y$$

$$= -4 - 1 * 0.4624 = -4.4624$$

Therefore the required AEP is $1\text{x } 10^{-4.4624} = 3.45 \text{ x } 10^{-5}$

'DERM-09'

Department of Environment and Resource Management

Guidelines for Failure Impact Assessment of Water Dams

June 2010

Prepared by:

Office of the Water Supply Regulator

Department of Environment and Resource Management

July 2010

#29384

Contents

1. Introduction

There is community concern regarding the potential for medium to large dams, including ring tanks and some weirs, to fail and threaten lives. In the past dam safety has been regulated by the *Water Resources Act 1989* and then superseded by the *Water Act 2000*.

New legislation, the *Water Supply (Safety and Reliability) Act 2008* (the Act), which supersedes provisions of the Water Act, received assent on 21 May 2008. The dam safety provisions of the Act commenced on 1 July 2008.

The Act details the provisions for referable dams and the process for determining whether a dam is referable or not. Dam owners need to check whether their dam is subject to this legislation. The Act requires owners of particular dams to assess the impacts of dam failure on the safety of people living downstream of the dam, by way of a dam failure impact assessment, to determine whether the dam is a referable dam. The new legislation also provides for regular ongoing assessment of the potential threat to people from unexpected flooding caused by a failure of one of these dams.

These guidelines are prepared pursuant to s. 342 of the Act for failure impact assessment of water storage dams and issued by the chief executive of the Department of Environment and Resource Management (DERM). The Act can be accessed on the internet at <www.legislation.qld.gov.au>.

This version of the guidelines are a simple update of the April 2002 guidelines updating the name of the department and the new legislation references. There are no fundamental changes to the basic failure impact assessment process methodology in this updated version of the guidelines.

1.1 Dam safety

Under the Act, the chief executive of DERM is responsible for the regulation of referable dams in Queensland.

The chief executive becomes involved in the assessment of applications for development permits that seek approvals to:

- build new referable dams or
- carry out operational works on existing referable dams that will increase the storage capacity of those dams by more than 10 per cent.

The chief executive has the power under the *Sustainable Planning Act 2009* (s. 244) to impose conditions relating to dam safety on development permits which approve the above dams and works. The development permit is attached to the land where the referable dam is located and binds the owner, future purchasers and any occupier of the land.

The chief executive also has the power under the Act to impose safety conditions on existing referable dams. The chief executive can modify these conditions if the chief executive believes that the changes are in the interests of dam safety. Safety conditions are taken to form part of a development permit for the dam and can be imposed regardless of whether the dam owner already has a development permit for the dam. They attach to the land where the dam is located and bind the owner, future purchasers and any occupier of the land.

The chief executive can also give directions to take stated action to an owner or operator of a referable dam by issuing a written notice. Such a notice will only be issued if:

- there is a danger of the dam failing and
- action is necessary to prevent or minimise the impact of the failure.

These notices also attach to the land where the referable dam is located, binding the owner of the land at the time it is issued and any future owners.

1.2 Guidelines—aims

The Guidelines for Failure Impact Assessment of Water Dams and the Queensland Dam Safety Management Guidelines for referable dams have been developed to help owners comply with the Act and dam safety conditions for referable dams (these include both conditions relating to dam safety imposed on development permits and safety conditions imposed under the Act).

The Guidelines for Failure Impact Assessment of Water Dams provide information about:

- referable dams
- failure impact ratings
- failure impact assessment and how it is done
- certification of a failure impact assessment

- lodging a failure impact assessment for an existing dam
- lodging a failure impact assessment for a new or proposed dam
- lodging a failure impact assessment for works on an existing dam
- timing requirements for undertaking failure impact assessments
- processes for accepting, rejecting or reviewing a dam failure impact assessment
- responsibilities, penalties and provisions for appeals.

More information on changes to the legislation and dam safety generally can be found in the Queensland Dam Safety Management Guidelines.

For further information on this guideline or the information outlined above, please contact:

Dam Safety
Office of the Water Supply Regulator
Department of Environment and Resource Management

Ph: (07) 3224 7215

<www.derm.qld.gov.au>

2. Overview—Requirements of the legislation

2.1 What is a dam failure?

A dam is considered to have failed when:

- a part or all of the dam physically collapses, for example, when:
  - the earth wall slumps
  - part of the wall erodes when overtopped
  - foundation weakness removes a section of a concrete dam wall.

or

- there is an uncontrolled release of any of the contents from the dam, for example, when:
  - a gate or valve fails
  - an outlet pipe breaks.

2.2 What is a failure impact assessment?

A failure impact assessment of a water storage dam is the process used under the Act to determine the number of people whose safety could be at risk should a dam fail (population at risk). The results of the assessment are used to determine:

- *whether a dam is referable and*
- the failure impact rating of a dam.

2.3 What is a failure impact rating?

A failure impact rating is a measure of the population at risk should a dam fail. There are two categories:

- Category 1— between two to 100 people at risk by the dam failing. All category 1 dams are referable dams under the Act.
- Category 2—more than 100 people at risk by the dam failing. All category 2 dams are referable dams under the Act.

If less than two people are at risk by the dam failing then the dam is not given a failure impact rating and is not referable under *the Act.*

The chief executive imposes dam safety conditions on referable dams based partly on the failure impact rating. Dam safety conditions can be imposed either when a development permit relating to a referable dam is granted or, after the dam has been constructed (as safety conditions under the Act, which are taken to form part of a development permit for the dam).

2.4 Who certifies a failure impact assessment as complete and accurate?

A failure impact assessment must be certified by a registered professional engineer, which is a person, company or unit registered under the *Professional Engineers Act 2002*. He or she is responsible for certifying, as specified in these guidelines, the:

- accuracy and content of a dam failure impact assessment
- adequacy and accuracy *of the modelling used to calculate the population at risk*
- accuracy of the assessed population at risk and other matters.

An assessment cannot be certified by an engineer who is:

- the owner of the dam being assessed or
- an employee of the owner of the dam or
- the operator of the dam or
- an employee of the operator of the dam.

2.5 How do you failure impact assess a dam?

An assessment can be done using one of the following methods:

2.5.1 Simplified assessment

This might typically be used when the flow of water proceeds down well-defined channels and when there is little doubt regarding the level of population at risk. For example, it might be used when:

- the dam is large and located upstream from a major urban population and where it is clear that more than 100 people would suffer the impact of dam failure (that is, the dam would have a category 2 failure impact rating) or
- the dam is small and there are no people at risk should the dam fail (that is, the dam would not be a referable dam).

2.5.2 Comprehensive assessment

This might be used when the flow of water proceeds down well-defined channels and when there is some uncertainty in estimates of the population at risk.

This is a detailed assessment and must include a dam break analysis for a range of dam failure scenarios such as overtopping, sabotage, seeping and piping failure.

A dam owner may choose to commission a comprehensive assessment even though a simplified assessment could be acceptable under these guidelines. However, the owner must undertake a comprehensive assessment if the registered professional engineer is:

- uncertain that the dam will have a category 1 or 2 failure impact rating and the owner wishes to justify the lower category 1 failure impact rating or
- uncertain that the dam will have a category 1 failure impact rating, or it is not a referable dam, and the owner wishes to justify the dam not being referable.

2.5.3 Two-dimensional flow analysis

This form of assessment might need to be used if the population at risk is situated close to a possible dam breach(es) location(s) and there is a risk that the population will be inundated by water from the dam before it concentrates in downstream channels. This method is likely to be needed for ring tanks.

2.6 Do I need to undertake a failure impact assessment to obtain a failure impact rating?

See Chart 1 (page 9).

Yes, if you are the owner of a dam that is not already assigned a category 2 failure impact rating and the dam:

- exceeds, or will after its construction, exceed the height and storage criteria specified in the Act (refer to 2.7) or
- is under notice from the chief executive to undertake a failure impact assessment of the dam (s. 343(5) of the Act). Notices will only be issued if the chief executive reasonably believes the dam will be given a category 1 or category 2 failure impact rating.

The failure impact assessment will be due:

- if the dam exceeds, or will after its construction, exceed the height and storage criteria specified in the Act:
  - if the dam has not already been assigned a category rating, it is due now
  - if the dam has already been assigned a category 1 rating, it will be due within the period stated in the notice of the acceptance of the previous failure impact assessment.
- If the dam is subject to a notice from the chief executive to undertake a failure impact assessment, by the due date stated in the notice.

2.7 Does my dam exceed the height and storage criteria specified in the Act?

Yes, if your dam is, or after construction will be:

- more than eight metres in height with a storage capacity of more than 500 megalitres or

- more than eight metres in height with a storage capacity of more than 250 megalitres and a catchment area that is, more than three times its maximum surface area at full supply level.

2.8 Do all dams that exceed the height and storage criteria specified in the Act require a failure impact assessment?

See Chart 1 (page 9).

Yes, unless it is:

- a dam which has already been assigned a category 2 failure impact rating or
- a dam which contains hazardous waste or
- a proposed dam which will contain hazardous waste or
- a weir that does not have a variable flow control structure on its crest.

2.9 Do I need to undertake a failure impact assessment if I want to increase the storage capacity of my dam?

Yes, if either:

- you are the owner of an existing referable dam and
- you want to carry out operational work that will increase the storage capacity of that dam by more than 10 per cent and
- your existing development permit for the dam does not authorise the carrying out of those works

or if:

- the dam did not previously exceed the height and storage criteria specified in the Act (refer section 2.7) and the increase in dam size means that the dam will exceed the criteria.

2.10 What if I receive a notice from the chief executive to undertake a failure impact assessment?

You must comply with the notice.

The chief executive can issue a notice requiring the owner of an existing dam, or a dam being constructed, to undertake a failure impact assessment (s. 343(5)). Notices will only be issued:

- for dams that do not meet the height and storage criteria specified in the Act (refer section 2.7) if the chief executive reasonably believes the dam will be given a category 1 or category 2 failure impact rating
- for dams that meet the height and storage criteria specified in the Act (refer section 2.7) if the chief executive reasonably believes the dam will be given a different rating category to that it was previously given and the reassessment under s. 345 of the Act is not yet due.

2.11 Who pays for the failure impact assessments?

See also Responsibilities 3.1

The owner of the dam must pay the cost of the failure impact assessment unless:

- the dam does not meet the size criteria in s. 343(1) of the Act and
- the assessment is undertaken in response to a notice(s. 343(5) of the Act) from the chief executive and
- the resultant assessment is accepted by the chief executive and
- in that assessment the dam is not given a failure impact rating and is therefore not a referable dam.

If applicable the chief executive will pay the reasonable costs of:

- preparing the assessment
- certifying the assessment
- any review of the assessment that occurs under s. 351 of the Act.

2.12 Who submits the failure impact assessment?

See Chart 1 (page 9) and Chart 2 (page 10)

The owner of the dam.

The owner must submit a failure impact assessment that has been certified by a registered professional engineer. The failure impact assessment must be carried out in accordance with these guidelines and clearly detail how the assessment was undertaken and justify the conclusion.

The failure impact assessment is then submitted to the chief executive of DERM for acceptance.

2.13 When must I submit my failure impact assessment if I plan to construct a new dam that exceeds the height and storage criteria specified in the Act?

See Chart 1 (page 9) and Responsibilities 3.4.

Prior to a development permit being submitted for approval.

You must ensure the failure impact assessment is completed, and accepted by the chief executive, before the development application is submitted to the assessment manager. The development application must be accompanied by a copy of the information notice accepting the failure impact assessment.

2.14 When must I submit my failure impact assessment if I plan to carry out works that will increase the storage capacity of my referable dam by more than 10 per cent?

- You must ensure the failure impact assessment is completed, and accepted by the chief executive, before work begins.
- You must also obtain a development permit approving the works before commencing, and supply evidence of the accepted failure impact assessment with the application for the development permit.
- In some cases, the Act will also require the chief executive to give written consent (as the water manager under the Act) to the development application being made. Consent will be required in cases where a water entitlement is required to operate the dam. The entitlement could be a water allocation, an interim water allocation or a water licence.

2.15 How often do I need to undertake a failure impact assessment once I have my failure impact rating?

See Chart 1 (page 9).

The notice issued by the chief executive accepting the FIA will state the period within which the owner must have another failure impact assessment carried out. The period must be at least five years if your dam:

- has a category 1 failure impact rating or
- is not given a failure impact rating in a dam failure impact assessment accepted by the chief executive, but your dam exceeds the specified height and storage criteria outlined in the Act (refer to 2.7).

Each five-year period runs from the date the last assessment was accepted by the chief executive.

For dams deemed to have a failure impact rating of Category 1 under the Water Regulation 2002, the first reassessment of the failure impact assessment was due on 20 April 2007.

A further dam failure impact assessment will also be required if your dam is a referable dam and you want to carry out operational work that will increase the storage capacity of the dam by more than 10 per cent and the existing development permit for the dam does not authorise the carrying out of those works. This further assessment is required because of the application for the development permit for the works to be carried out must be supported by evidence the chief executive has accepted a dam failure impact assessment for the dam.

A further dam failure impact assessment will also be required if you are given a notice by the chief executive to have your dam failure impact assessed (s. 343(5)).

Further dam failure impact assessments are not required if:

- your dam has a category 2 failure impact rating as it is considered unlikely that such a dam would be given a lower rating if reassessed

- the chief executive issued you with a notice under s. 343(5) to have your dam failure impact assessed, the dam failure impact assessment is accepted by the chief executive, the dam is assessed as not having a category 1 or category 2 failure impact rating (that is, it is not a referable dam), and the dam does not meet the specified height and storage criteria outlined in the Act.

2.16 When must I submit my failure impact assessment if I receive a notice from the chief executive requiring me to undertake a dam failure impact assessment?

The notice you receive will state the date when the failure impact assessment must be submitted.

2.17 What details must be included in the written failure impact assessment?

See Section 5 on page 35 for a complete list.

However in general the assessment must include:

- general information (for example, name of owner, operator, address, geographical location etc.)
- catchment area details
- dam description
- data and analysis
- results of failure impact assessment (include detailed discussion)
- registered professional engineer's written certification.

2.18 What happens to my failure impact assessment once it is submitted?

See Chart 2 (page 10) and Responsibilities 3.3.

The chief executive of DERM can:

- accept a failure impact assessment or
- reject a failure impact assessment or
- require a review of a failure impact assessment.

A failure impact assessment may be rejected or a review of it may be required if it is:

- not completed in accordance with these guidelines
- incomplete in a material particular (for example, the assessment is not certified by a registered professional engineer)
- incorrect in a material particular (for example, the assessment did not take into account downstream residential development).

The owner of the dam will be given written notice of the chief executive's decision.

Before requiring a review of, or rejecting an assessment, the chief executive can request additional information about the assessment.

If a failure impact assessment is not initially accepted and is then reviewed, corrected or completed, it will need to be recertified and resubmitted.

Details of the process for accepting, rejecting or reviewing a failure impact assessment are presented in Chart 2 on page 10 (including the appeals process against the chief executive's decision).

2.19 What happens if I don't do a dam failure impact assessment as required?

See responsibilities 3.1 and 3.2.

A dam owner may be prosecuted for failing to comply with the Act if he or she fails to carry out and submit a failure impact assessment as required. Penalties may also apply if a person gives information which is false or misleading to the registered professional engineer certifying the dam failure impact assessment or if the registered professional engineer certifies a dam failure impact assessment the engineer knows is false or misleading.

2.20 What happens to my waterworks licence issued under the *Water Resources Act 1989*?

For dams which are no longer referable

Owners may find that their dam, which was referable under the *Water Resources Act 1989* and had a waterworks licence, is not referable under the *Water Act 2000* and subsequently the *Water Supply (Safety and Reliability) Act 2008*. The Water Act transitioned existing hazardous waste dams licensed under the repealed Water Resources Act as licensed environmentally relevant activities with dam safety conditions being deemed to be conditions of the dam's environmental authority or development approval.

However, take note that there may be certain waterworks licence conditions which still apply. For example:

- If your dam was licenced under the *Water Resources Act 1989* and is no longer considered to be a referable dam, conditions on the waterworks licence other than dam safety conditions may still continue to apply (for example, conditions dealing with the interference with the flow of water in a watercourse continue to apply).

For dams which are still referable

If your dam was licenced under the *Water Resources Act 1989* and is still a referable dam under the Act, the licence for that dam will be taken to be a development permit approving the dam. Any safety conditions issued as part of the existing waterworks licence continue to apply and form part of the development permit.

Chart 1: How to determine if your dam is referable and when a dam failure impact assessment is required

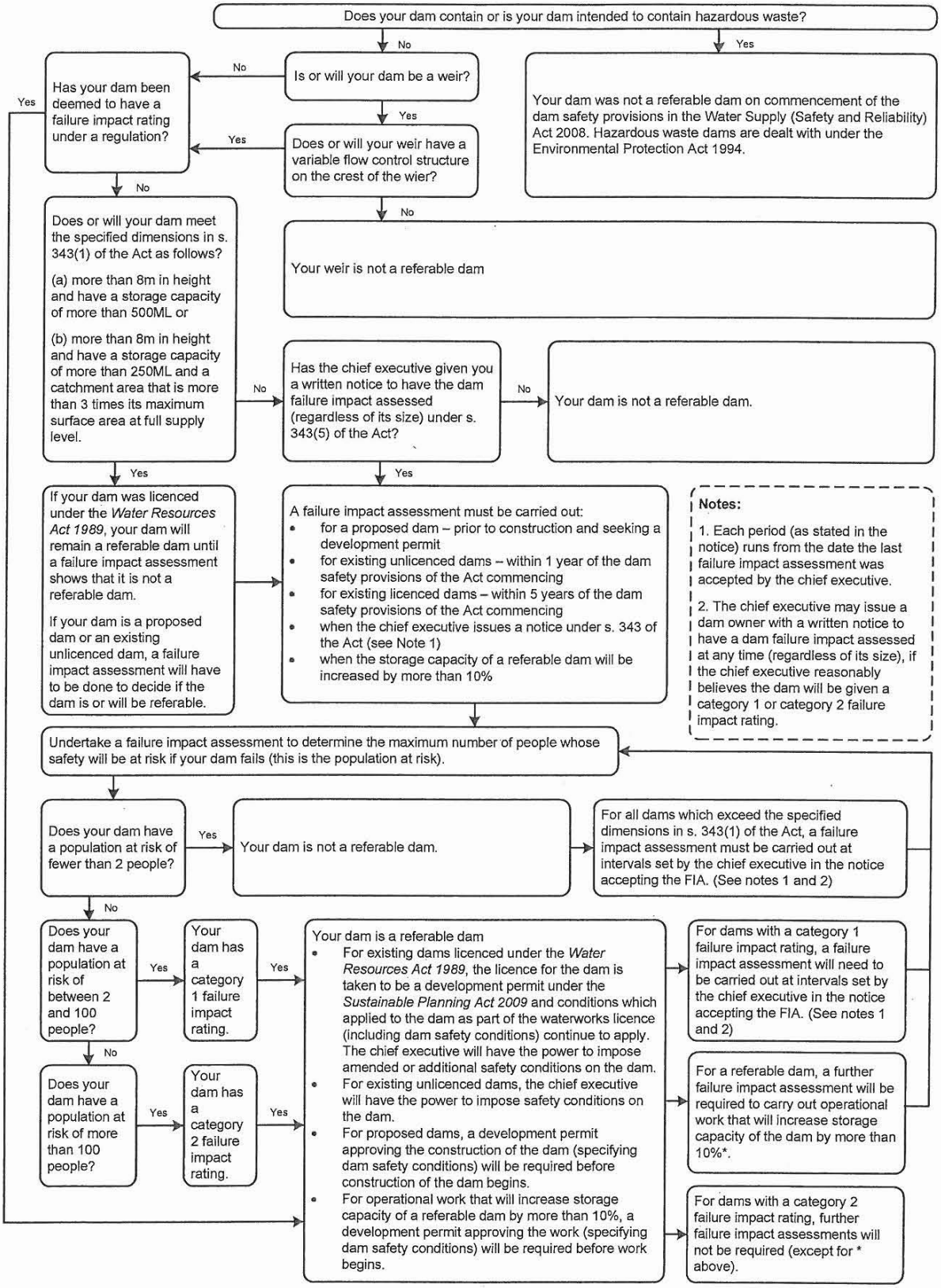
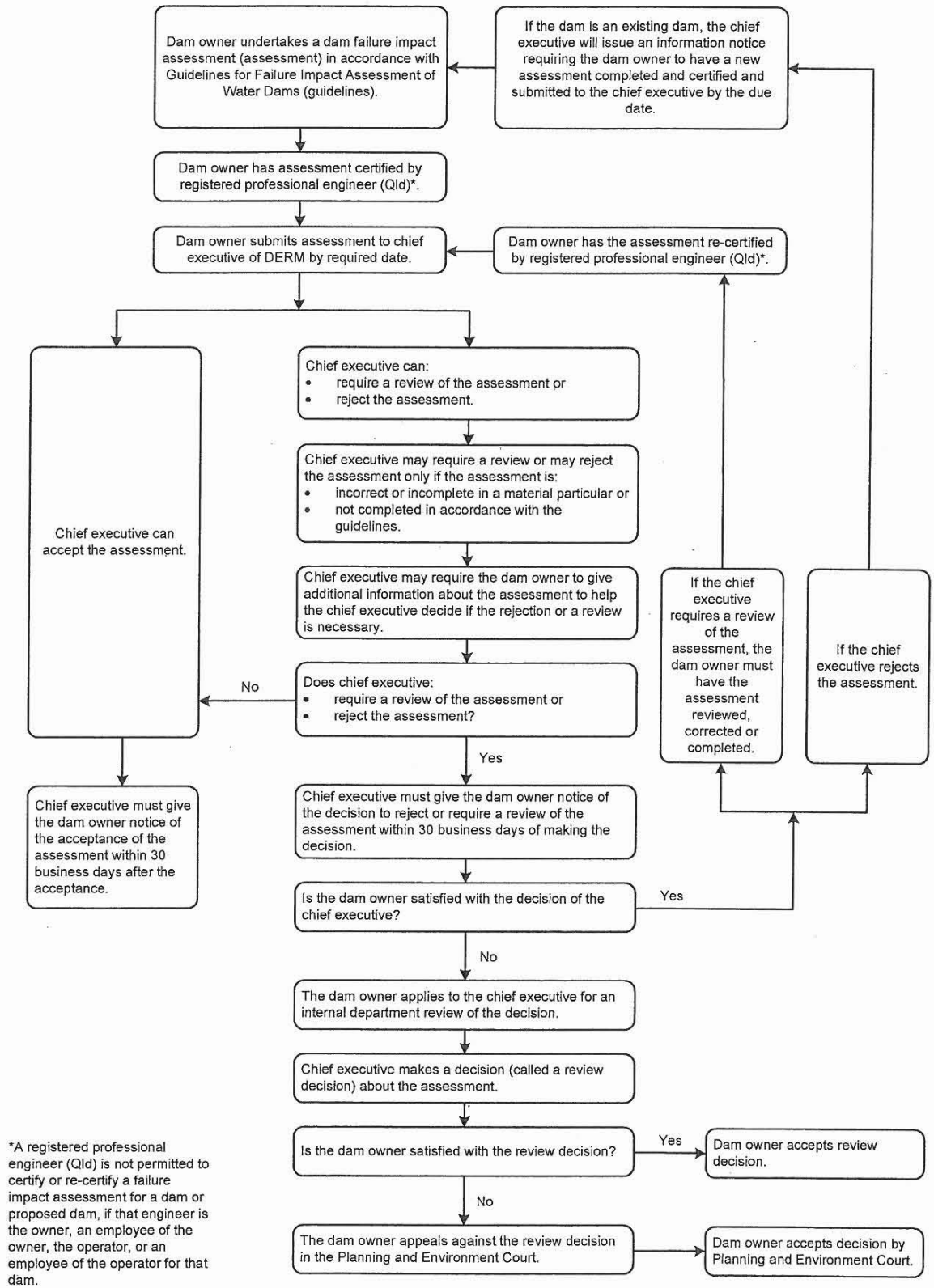


Chart 2: Process for accepting, rejecting or reviewing dam failure impact assessments



*A registered professional engineer (Qld) is not permitted to certify or re-certify a failure impact assessment for a dam or proposed dam, if that engineer is the owner, an employee of the owner, the operator, or an employee of the operator for that dam.

3. Responsibilities

3.1 Responsibility of the owner

A failure impact assessment must be undertaken by a dam owner if the dam is not deemed to have a failure impact rating under a regulation and:

- the dam exceeds the specified height and storage criteria outlined in the Act (refer to 2.7) or
- the dam owner is issued with a notice by the chief executive of DERM under s. 343(5) of the Act.

Section 343(2) of the Act requires the owner of a dam that is not referable to have the dam failure impact assessed if, because of any works proposed to be carried out in relation to the dam, the dam will meet the height and capacity criteria in s. 343(1) after the works are carried out.

If works are proposed that would increase the capacity of a non-referable dam (which meets the height and capacity criteria in s. 343(1) of the Act) by 10 per cent then the owner of the dam must have the dam failure impact assessed (s. 343(3) of the Water Supply Act),

The owner of a referable dam must have the dam failure impact assessed if the storage capacity of the dam will increase by more than 10 per cent after proposed works are carried out (s. 343(4) of the Water Supply Act).

The Act sets out timing requirements for dam failure impact assessments (see Chart 1, page 9).

The chief executive sets the timeframe when further failure impact assessments are required (see Chart 1, page 9). The owner must ensure another assessment of the dam is completed and given to the chief executive within the period set by the chief executive after the last assessment was accepted by the chief executive. The timeframe for further failure impact assessments must be no less than five years (s. 345(2)). Such assessment must be undertaken by a dam owner if:

- the dam is given a category 1 failure impact rating in an assessment accepted by the chief executive, or
- the dam is not given a failure impact rating in an assessment accepted by the chief executive, but the dam exceeds the height and storage criteria specified in the Act or
- the dam owner is given a notice to have the dam failure impact assessed under s. 343(5) or
- the dam is given a category 1 or category 2 failure impact rating in an assessment accepted by the chief executive, and the owner wants to carry out operational work that will increase the storage capacity of the dam by more than 10 per cent and those works are not authorized by the existing development permit for the dam.

A further failure impact assessment does not apply to the owner of:

- a dam given a category 2 failure impact rating under the last assessment of the dam, or
- an existing dam, or a dam being constructed that was issued a notice by the chief executive to have the dam failure impact assessed, where it was not given a category 1 or category 2 failure impact rating, or
- the dam does not meet the criteria of more than eight metres in height and have a storage capacity of more than 500ML, or a storage capacity of more than 250ML and a catchment area that is more than three times its maximum surface area at full supply level.

The owner of the dam must pay for a dam failure impact assessment, unless the chief executive requires the owner to carry out a dam failure impact assessment (under s. 343(5) of the Act) on a dam that does not meet the size criteria in s. 343(1) and subsequently the assessment is accepted by the chief executive and the dam is assessed as not being referable. In these circumstances, the chief executive must pay the reasonable cost of preparing and certifying the dam failure impact assessment.

A development permit may be required as per section 3.4 of these guidelines.

Please note that the provisions of the Act relating to referable dams and flood mitigation do not affect the liability of a dam owner or operator for any loss or damage caused by the failure of a dam or the escape of water from a dam.

3.2 Responsibility of the certifying engineer

A registered professional engineer must certify each failure impact assessment. Penalties apply if a registered professional engineer certifies a failure impact assessment that contains information that the engineer knows is false or misleading and does not disclose this.

The written certification must state:

- that the assessment has been prepared in accordance with these guidelines and that it is not based on information that the registered professional engineer knows is false or misleading
- that the certifying registered professional engineer is not the owner, an employee of the owner, the operator, or an employee of the operator of the dam being assessed
- that it is an accurate estimate of the population at risk and that the estimate is consistent with:
    - the detail and accuracy of the modelling used
    - the extent of the failure impact zone
- the certifier's judgment of the appropriateness and accuracy of the information included in the assessment
- the certifier's view of the veracity of the information included in the assessment, as well as specifying the information on which the assessment was made
- that the certifier is satisfied that the inspection of the site has accounted for sufficient points of impact, covering the failure impact zone as a minimum, to justify the failure impact rating
- that the certifier is satisfied with the locations of cross-sections and the intervals between those cross-sections for each individual numerical model generated for the dam failure impact assessment.

For failure impact assessments completed following an initial assessment accepted by the chief executive (that is, the second and subsequent assessments), it may be permissible to use the same inundation data used in the previous assessment of the population at risk. However, the registered professional engineer's certification must include justification of this approach in the reassessment (refer to section 4.8 for details).

3.3 Responsibility of the chief executive

See Chart 2 (page 10).

The chief executive may accept, reject, or require a review of a failure impact assessment. If a failure impact assessment is accepted and the dam is referable (that is, it has a category 1 or a category 2 failure impact rating), the chief executive may impose dam safety conditions on the dam. Dam safety conditions can be imposed either when the development permit for the dam or for works proposed to be undertaken on the dam is granted (as development permit conditions), or after the dam has been built (as safety conditions).

The chief executive may reject or require a review of a failure impact assessment if the assessment:

- has not been completed in accordance with these guidelines or
- is incomplete in a material particular (for example, the assessment is not certified by a registered professional engineer) or
- is incorrect in a material particular (for example, the assessment did not take account of downstream residential development)[1]

The chief executive may require the dam owner to supply additional information to assist in the decision to reject or require a review of the assessment.

The owner of the dam will be given written notice within 30 business days of a decision being made to accept, reject or require a review of the failure impact assessment.

If the chief executive requires a review of the assessment, the dam owner must review, correct or complete the failure impact assessment, have it re-certified by a registered professional engineer and resubmit the assessment by the date specified in the information notice.

[1] The chief executive reserves the right to check the accuracy of an assessment, although the certifying registered professional engineer retains responsibility for the accuracy of the assessment.

If the chief executive rejects an assessment relating to an existing dam, the dam owner must prepare a new failure impact assessment, have it certified by a registered professional engineer and submit the assessment by the date specified in the information notice.

If the chief executive rejects an assessment relating to a proposed dam, the dam owner will not be required to complete a new assessment by a specified date. However, if the proposed dam meets the height and storage criterion outlined in the Act (refer section 2.7), it will still be necessary for the dam owner to obtain an accepted failure impact assessment before-

a. a properly made application for a development permit is made, and

b. before construction of the dam begins

A dam owner may apply to the chief executive for an internal review of the decision, if the chief executive requires a review of, or rejects, a dam failure impact assessment. The chief executive will then review the failure impact assessment and make a review decision (see Chapter 7 of the Act).

If a dam owner is not satisfied with the review decision, the appeal provisions of the Act allow the owner to appeal this decision in the Planning and Environment Court (see Chapter 7 of the Act).

3.4 Responsibilities under the *Sustainable Planning Act 2009*

A development permit must be obtained if a person wants to carry out operational work, that is, the construction of a new referable dam or that will increase the storage capacity of a referable dam by more than 10 per cent. A development permit is an approval under the *Sustainable Planning Act 2009*, which allows particular development (for example, construction of a new referable dam) to occur. A development permit may impose conditions (for example, safety conditions) on the approved development.

A development permit is only issued after a development application has been assessed and approved using the Integrated Development Assessment System (IDAS) under the Sustainable Planning Act.

A development application for the construction of a new referable dam or for carrying out operational work that will increase the storage capacity of a referable dam by more than 10 per cent must be lodged with an assessment manager, who is then responsible for administering the assessment and approval process[2]. The development application must be supported by evidence the chief executive has accepted a failure impact assessment for the dam (refer to s. 561 of the Act). Additionally, if a water entitlement is required under the Act to operate the dam (for example, the proposed dam is on a watercourse) the development application must be accompanied by the chief executive's written consent (as the water manager under the Act) to the application being made.

The assessment manager for a development application for construction of a new referable dam or for operational works that will increase the storage capacity of a referable dam by more than 10 per cent will generally be the local government if its planning scheme makes the construction of the new dam, or the carrying out of the operational works, assessable development. If the local government does not make the dams' construction, or the operational works assessable development under its planning scheme, a regulation under the Sustainable Planning Act may make the chief executive the assessment manager. Even in those cases where the chief executive is not the assessment manager, the chief executive will have the power to require dam safety conditions to be imposed on the development permit.

In some cases, a dam may become referable after it is constructed (for example, if the chief executive issues a s. 343(5) notice to have the dam failure impact assessed and the dam is assessed as having a category 1 or category 2 failure impact rating). In these cases, the chief executive has the power to impose safety conditions on the dam under the Act and these are taken to be part of a development permit for the dam. However, as the dam was not a referable dam prior to its construction, there is no requirement for the dam owner to apply for a new development permit under the Sustainable Planning Act.

[2] The appeal provisions of the Sustainable Planning Act allow appeals in the Planning and Environment Court against the decision made about the development application.

4. Methodology

4.1 Introduction

The owner needs to undertake (possibly in conjunction with a registered professional engineer) the following activities when preparing a failure impact assessment:

- the dam site needs to be inspected at least once
- data needs to be collected and its appropriateness and accuracy assessed
- the dam failure zone must be identified and an assessment of the population at risk calculated
- finally, the failure impact assessment needs to be certified by a registered professional engineer and submitted to the chief executive.

4.2 Dam site inspection

Site inspections are mandatory. These ensure that the information upon which the failure impact assessment is based is correct and up to date, and also enable an appreciation of the characteristics of the site. The date(s) and name(s) of the personnel involved in the site inspection must be included in the failure impact assessment.

Site inspections must include areas that could be affected by dam failure both upstream and downstream of the dam. Site inspections are needed to:

- verify the accuracy of all mapping/aerial photogrammetry or satellite imagery that is, used in the assessment
- verify the existence of buildings and other places of occupation to justify the failure impact rating identified in the assessment
- identify other storages on the same waterway
- identify buildings and other places of occupation along waterways, which may house population at risk (for example, camping facilities)
- identify catchment modification works (for example, diversion drains and levee banks).

The registered professional engineer certifying the failure impact assessment must be satisfied that the inspection of the site has accounted for sufficient points of impact, covering the failure impact zone as a minimum, to justify the failure impact rating. The registered professional engineer must include a statement to this effect in the certification.

Less rigour will be required for a failure impact assessment where a dam obviously has a category 2 failure impact rating (as this is the highest rating applicable) than if a dam is either on the border of not being referable or on the border of having a category 1 failure impact rating[3] and the owner wishes to justify the adoption of the lower failure impact rating.

4.3 Data collection

The registered professional engineer certifying the failure impact assessment must judge the appropriateness and accuracy of the information included in the assessment and indicates in the certification, the engineer's views on the assessment information.

A wide array of information needs to be collected to determine the effects of a dam failure as detailed below.

4.3.1 General information

Floods due to dam failure are generally significantly larger than natural floods. They can rise very rapidly, form steep wave fronts and carry large amounts of debris and sediment.

Flood information can be used in the assessment including:

- available historic flood levels
- hydrographic data

[3] Note: A detailed inundation map may still have to be produced as part of the preparation of an Emergency Action Plan for the dam.

- rainfall/runoff model results
- dam break flood model results under sunny day and incremental conditions.

4.3.2 Dam and storage information

Information should be gathered which outlines the dam's physical dimensions used to determine potential breach characteristics and incremental flooding effects (for example, stability of slopes, earthquake effects, condition of components, materials and spillway capacity). Such information should include:

- type of dam and location (including latitude and longitude)
- spillway type and adequacy (including flood control facilities such as gates and secondary spillways)
- dimensions such as height and length of embankments and the width of the crest
- storage capacity to full supply level and to the crest of the dam (stage capacity curve)
- use of dam including contents of the storage area
- possible causes and modes of failure
- comments on design, foundations and any unusual conditions
- design studies or reports.

4.3.3 Topographic information

Topographic information can be sourced from a number of areas, with the decision as to which data is used being based on issues such as the availability, relevancy and accuracy of the information. Sufficient topographic information must be obtained to accurately determine:

- the shape and slope of the valley downstream of all potential failure locations
- controls on the downstream flow, such as culverts, vegetation, weirs, bridges, embankments, surface roughness and temporary storage on the flood plains
- location of major downstream tributaries.

If regional maps do not provide sufficient detail for a failure impact assessment, further information may need to be obtained from sources such as:

- road maps
- orthographic, topographic, military and cadastral plans
- surveyed cross-sections
- aerial photographs
- satellite imagery
- local residents.

Orthographic maps, if they exist, are generally very useful for failure impact assessments as they combine contour information with images of buildings, roads etc. Contours can be used as flood level indicators.

It is important to note that mapping or aerial photogrammetry may not contain recent developments, for example, houses or other places of occupation (refer to Appendix A). Information contained in photogrammetry that plays an integral role in the assessment must be verified by site inspections.

For dam break models where the need for precision is not great, model cross-sections may be based on existing survey information such as stream strips, cross sections, and the most reliable topographic maps available. It may also be possible to extend survey cross sections by using contours from maps etc.

Cross sections may need to be taken at locations where there are buildings or other places of occupation as well as at sufficient other locations, including hydraulic controls such as bridges, weirs, waterfalls, to allow reasonable dam break models to be established.

As a guide to cover the inundation area, the cross sections should extend for at least half the vertical height of the dam above the stream bed at each location. This height of the cross-sections may be able to be decreased at greater distances downstream of the dam.

Where extreme precision is required, extensive, detailed surveys of the downstream valley may be necessary. In such circumstances, surveys may also be required to locate and determine natural surface levels at all buildings or other places of occupation that are thought to be at risk.

4.3.4 Hydrographic data

The inflow hydrograph into a storage during a flood event can affect the results of a dam break analysis. Its impact will depend on a number of parameters such as:

- the size of the available flood storage
- the height of the dam
- the size and capacity of its spillway
- the shape of the valley downstream of the dam.

For lower accuracy analyses, only one roughness coefficient might be sufficient in representing the whole floodplain at each cross-section. In such analyses, it might also be appropriate to adjust roughness coefficients using text book allowances.

To obtain an indication of model sensitivity to variation of the assumed roughness the model must be run with values of Manning's 'n'[4] varying either side of the adopted roughness coefficient.

Some of the potential errors in hydrographic data include:

- extrapolation of existing flood data to predict a much larger, deeper and faster flood
- short circuiting of the much higher flows at loops in a watercourse resulting in a shorter effective flow length
- selecting channel cross-sections that do not accurately represent a watercourse channel
- excluding the effects of the flood wave on the storage in the tributary creeks and other near stream storages
- excluding distributory flows.

Where previous flood records exist in the river or stream reach under consideration, the hydraulic model should be calibrated to match the available flood inundation data so that the numerical dam break model can be demonstrated to approximate actual flow conditions. If these records are not available, or are available for a limited range of flows, some assessment must be made of the potential impact on the accuracy of the modelled results. All modelling must be subjected to sensitivity analyses to test sensitivity to model assumptions.

Hydrographic characteristics of each study reach must be assessed and validated using aerial photography (where available) and site inspections.

4.3.5 Hydrologic data

Downstream tributary inflows may impact on the dam break flood, particularly if population centres are some distance downstream of the dam. Simpler analyses on smaller dams would not normally consider inflows from tributaries downstream of the dams. Concurrent rainfall to produce downstream tributary flows should be based on the lesser of the following rainfalls over the tributary catchments (see Table 1 below).

Table 1

Annual exceedance probability (AEP) of dam break flood rainfall	**Annual exceedance probability of concurrent rainfall**
$1.0\ e^{-3}$ or greater	Does not need to be considered
$1.0\ e^{-3}$ to $1.0\ e^{-5}$	AEP of dam break flood rainfall multiplied by 1000
$1.0\ e^{-5}$ or less	0.01

[4] Manning 'n' is a roughness parameter used to model energy losses in streams. Unless reasonable discharge and water level calibration is available, reference should be made to standard hydraulic engineering texts for appropriate values of Manning's 'n'.

4.3.6 Downstream community information

Downstream community information must include the location, number and nature of buildings and other places of occupation (for details see Appendix A) and approved camping and recreational areas in the failure impact zone.

This information may be obtained from maps, persons with local knowledge and emergency action plans for the dam. Recent aerial photogrammetry also provides useful information on the location of downstream structures. As stated above, site inspections must be undertaken to verify downstream community information to ensure the information is up to date and identifies buildings and other places of occupation obscured by trees.

4.4 Determination of failure impact zone (see also analytical techniques)

The failure impact zone is the area affected by flooding as a result of the failure of the dam. The magnitude of the flood impact is determined by the difference between the flood impacts associated with a particular event with dam failure and the same event without dam failure. Failure impact zones must be determined for all:

- failure events specified within the analytical technique used for the failure impact assessment (refer to Box 1) and
- for all other failure events relevant to the dam.

The failure impact zone ends when the:

- flood caused by a dam failure is retained within the bed and banks and no more people (including people on boats) are at risk downstream or upstream or
- difference between the flooding effect with dam failure and the flooding effect without dam failure (that is, the incremental effect of the dam failure on the impacted zone) is less than 300 millimetres.

It should be noted that:

- While the dam failure impact zone is generally located downstream, areas upstream can also be affected and should be included where relevant (for example, an upstream area may be affected by the abnormal operation of discharge control devices such as gates or inflatable bags).
- Where people work in a mine pit, excavation or local depression below the dam that would fill after dam failure to the point it would inundate the people, they would be considered to be in the failure impact zone unless there was a prepared path of escape that would not be blocked by inflows.
- In some circumstances (for example, during a ring tank failure) a dam breach may discharge onto a flood plain before the flow concentrates into a downstream channel. In such a situation there may be areas where the incremental flooding is more than 300 mm, separated by areas where the incremental flooding is less than 300 mm. When determining the failure impact zone, all areas where the incremental effect is 300 mm or higher must be included.
- Where a dam has multiple segments such as a main embankment and one or more saddle dams, failure of each of these segments must be considered for its effect on the failure impact zone. The case producing the maximum population at risk must be used to determine the failure impact rating.

A map showing the extent of the failure impact zones must be included in the written assessment.

4.5 Population at risk

People are considered part of the population at risk if:

- they occupy buildings or other places of occupation that lie within the failure impact zone and
- any part of the ground where these buildings or other places of occupation are located would be covered by 300 mm or more of water.

When the failure impact zone is being determined, the number, location and nature of buildings and other places of occupation must be identified. A particular population at risk is determined by allocating default populations to each such site depending on its nature. (See Appendix A for default populations). For example, a detached house has a default population of 2.9 people. If 10 detached houses were inundated by 300 mm or more of water (and there was no natural flooding at the time) and these were the only buildings or other places of occupation located in the failure impact zone, the population at risk for that dam failure event is 29 people.

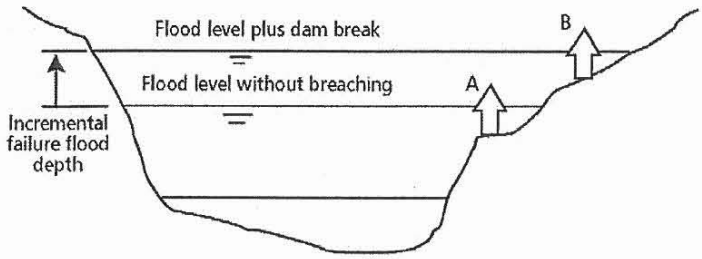
Note: The written assessment must state the nature of the site and justify the populations used for those places of occupation not listed in Appendix A.

The population at risk is the difference between the population at risk for a specific dam failure and the population at risk for the same flood had dam failure not occurred (that is, the incremental population at risk). The failure impact rating is determined using the highest incremental population at risk from a range of failure events relevant to the dam.

For example:

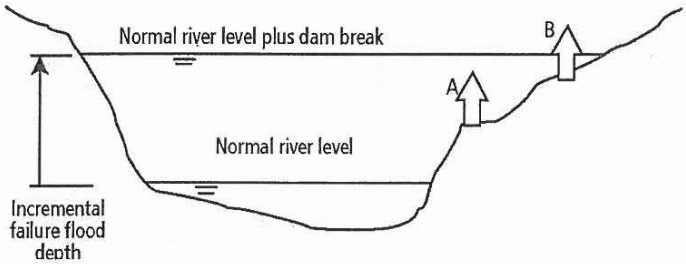
- Dam failure during a flood: 170 people are at risk from a dam failure, and 20 of those people are at risk from the natural flooding even if dam failure does not occur; it follows that 150 people are at risk if the dam fails (that is, 170 people minus 20 people). In the diagram below, house A is not included in the population at risk assessment for this event as it is inundated by natural floodwater. House B is included in the assessment of population at risk if the ground on which the house is located is inundated by at least 300 mm.

Figure 1—Dam failure during a flood



- A sunny day dam failure (when flooding is due to dam failure only): if 40 people are at risk from a dam failure, the population at risk is 40 people as nobody is at risk if the dam does not fail. In the diagram below, houses A and B are included in the assessment of population at risk if any part of the ground on which the houses are located is inundated by at least 300 mm.

Figure 2—Sunny day dam failure



4.6 Accuracy of population at risk calculations

A variety of factors may affect the accuracy of population at risk calculations. These must be considered to ensure the reliability of population at risk calculations. Factors include:

- the accuracy of cross-sections used in the analysis
- the locations of cross-sections used in the analysis
- the accuracy of the hydraulic modelling
- availability and accuracy/reliability of calibration data and the degree of extrapolation required to model dam break flows
- assumed hydraulic roughness parameters
- assumed breach development times
- locations, numbers and elevations of buildings and other places of occupation.

Sensitivity analyses or sensitivity tests assess the potential impact of some factors on the size of the population at risk and are normal practice for dam failure impact assessments. For example:

- What if the elevations of buildings or other places of occupation are at the lower bounds of the accuracy of the available survey information (for example, the accuracy of contours used to assess flood inundation is 2 metres)?
- What is the population at risk if all buildings or other places of occupation were 2 metres lower than assumed in the analysis?

- Does the population at risk change if conservatively short breach formation times are used?
- Does the population at risk change if conservatively high stream channel roughness parameters are used?

The degree of conservativeness should reflect the amount of calibration data available to determine stream channel roughness for the watercourse reaches in question.

The written dam failure impact assessment should include a statement on the range of the estimate of population at risk for the critical case. Such an assessment should indicate values for the upper limit of population at risk that could reasonably be expected as a result of the analysis and a similarly derived lower limit of population at risk.

4.7 Analytical techniques

4.7.1 Introduction

Three analytical techniques may be used in preparing dam failure impact assessments. These are two-dimensional flow analysis, simplified assessment techniques and comprehensive assessment techniques. These techniques may be used alone or in combination. Certifying registered professional engineers need to be satisfied that the techniques selected and the accuracy of the models developed are reasonable for the situations under consideration (see Box 1 and refer to section 2.5).

4.7.2 Two-dimensional flow analysis

This analysis will typically need to be used downstream of ring tanks and gully dams where embankments are close to buildings or other places of occupations that may be inundated by dam failure. This analysis calculates the extent of inundation on a local scale prior to the flow entering the main watercourse. This typically occurs on flood plains where there are few or no defined gullies for dam break floodwater to follow. Additionally this technique may be used close to gully dam abutments where failure may inundate buildings and other places of occupation immediately downstream of the dam.

Two-dimensional flow analysis takes curvilinear flow paths into account as flow discharges from the breach and spreads out downstream. Models used in such analyses need to be able to simulate the dynamic behaviour of overland flow over complex geometries. There are a number of models that are capable of being used to determine these local effects. These include those based on the shallow water wave equations such as those discussed in Wang et al (2000) and Zoppou and Roberts (1999). A number of standard commercial software packages are also capable of determining inundated areas for two-dimensional flow (for example, MIKE21—Danish Hydraulic Institute, DELFT-FLS—Delft Hydraulics).

Details on dam breach mechanisms for two-dimensional flow analyses are detailed in section 4.7.5.

Box 1 Minimum failure events which must be considered in the failure impact assessment

Two dimensional flow analysis and comprehensive analysis

- sunny day dam failure where the failure occurs at the full supply level and there is no concurrent flooding
- if the probable maximum flood (or lesser flood event) overtops the dam, assume the dam fails with the water level at the crest of the non-overflow section of the dam embankment. Where there is no defined non-overflow section, failure levels up to the headwater level produced by the Acceptable Flood Capacity headwater level is to be considered (refer to DERM, 2010).
- if the probable maximum flood does not overtop the dam, assume the dam fails with the water at the level of the probable maximum flood
- if the dam is filled through pumping, assume failure at the crest level occurs (from pumping alone) when the pumps fail to stop pumping
- failure due to the maloperation or malfunction of flow control structures. If the dam has the capability to significantly vary flood discharges through crest gates, sluices or some other type of variable flow control structures, the possibility of either failure or malfunction of these structures must be considered
- where there are premises between the sunny day impact zone and the highest natural flood levels, intermediate flood events are to be considered when the no failure flood levels falls just below buildings and other places of occupation that would be inundated with dam failure.

Simplified assessment

- sunny day dam failure where the failure flood occurs with the storage at full supply level and there is no other concurrent flooding
- dam crest flood when failure occurs during a flood event or during pump filling with the water level at the crest of the non-overflow section of the dam embankment
- where there are premises between the sunny day impact zone and the highest natural flood level, intermediate events are to be considered when the no failure flood levels fall just below buildings and other places of occupation that would then be inundated with dam failure.

4.7.3 Simplified assessment

A simplified failure impact assessment technique may be justified where there is little doubt as to the population at risk and the cost of a comprehensive assessment is anticipated to be high relative to the potential benefits. It involves the conservative use of topographic and hydrographic data and an empirically determined breach discharge.

This is an approximate technique, which uses the normal depth at a section to estimate maximum flood levels at a point for a given discharge. As such this technique does not take any backwater effects into account. It must not be used where backwater effects are expected to be significant in terms of the affected population at risk. Aside from the backwater effects, the principal areas of uncertainty are the accuracy of the stream slopes, the cross-sections, and the locations and levels of the impacted buildings.

Unless more accurate techniques are used which result in the breach size indicated in section 4.7.5, the maximum breach discharge from a dam during a breaching event, QBREACH must be determined using Equation 1. The empirical discharge relationship is based on the failure of a typical homogeneous earthfill embankment.

Equation 1 $Q_{BREACH} = 2.5\ F\ V^{0.76} H^{0.1}\ m^3/sec$

where:

F = 1.3 a factor to account for the simplified nature of the assessment

V = total volume of water released (in megalitres)

H = maximum depth of water in the storage (in metres)

Where a case for assessing population at risk includes flow through dam spillways or other discharge points, an additional flow Q_{DCF} must be added to the breach discharge. This additional flow will include the total discharge through any dam spillways with the appropriate storage level for the failure event.

If alternative techniques are applied to determining the dam discharge, the factor F must still be applied to the breach discharge.

For embankments exceeding 12 metres in height or embankments made up of non-cohesive materials such as gravels or ash, the breach characteristics may differ and the expected peak discharge must be adjusted accordingly.

A survey of the cross-sections at buildings or other places of occupation that could be affected is normally required. Survey data may be relative to the creek bed at the cross section under consideration. The distance of the sections downstream of the dam should also be determined using aerial photography or available maps.

The water level at any particular cross-section resulting from the discharge from a dam breach should be consistent with the normal depth for the section using the maximum breach discharge and Equation 2:

Equation 2 $$Q = \frac{R^{2/3}\ S^{1/2}}{n} A$$

where:

R = hydraulic radius = A/P (metres)

S = stream slope (metres/metre)

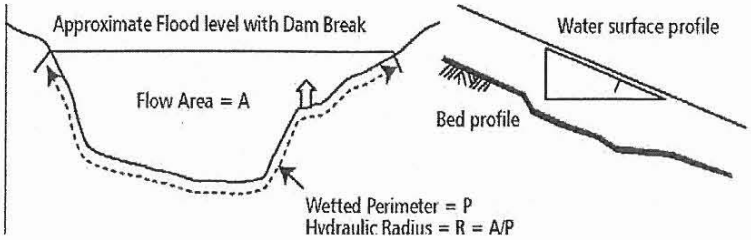
A = flow cross-sectional area (square metres)

P = wetted perimeter of cross-section (metres)

n = Manning's number[5]

[5] Manning 'n' is a roughness parameter used to model energy losses in streams. Unless reasonable discharge and water level calibration is available, reference should be made to standard hydraulic engineering texts for appropriate values of Manning's 'n'.

Figure 3—Parameters for water level determinations for simplified assessment



When sufficient depths at downstream sections have been determined the results should be plotted on a map. Interpolation between calculated points should be based on the accuracy of prevailing topography and contours.

4.7.4 Comprehensive assessment

If a simplified assessment is not accurate enough to adequately calculate the population at risk, then a comprehensive dam break analysis may be required. A comprehensive assessment is a detailed assessment of the failure impact zone and the population at risk if the dam fails. Dam break analyses must be undertaken for a range of dam failure scenarios (refer to Box 1) and use current hydraulic modelling practice and suitably documented and validated numerical models. Software capable of being used to carry out dam break analysis includes:

- BOSS FLOODWAV—International NWS DAMBRK (Version 3.0)
- Danish Hydraulics Institute—MIKE FLOOD
- RUBICON

Some estimate of the accuracy of each model must be made and this accuracy must be taken into account in assessing potential population at risk as indicated in section 4.6. The impact on population at risk will be greatest in areas with higher populations (for example, towns), and it may be justified to selectively improve accuracy in these areas.

Initially, cross-sections should be taken at or near the intervals shown in Table 2. However, the registered professional engineer certifying the assessment must be satisfied with the locations of cross-sections and the intervals between these cross-sections for each individual numerical model generated for the failure impact assessment.

Table 2

Storage (megalitres)	Indicative intervals between cross-sections	Indicative total distance downstream
20,000	1 kilometre	Up to 60 kilometres
2000	0.5 to 1 kilometre	Up to 20 kilometres
200	Not greater than 0.5 kilometre	Up to 5 kilometres

The total distances downstream in Table 2 are based on actual dam break studies indicating the distances downstream where the incremental effects of the dam break flood become relatively small.

Care should be taken to treat each case as site specific, particularly where the downstream valley is confined and narrow for great distances. In these cases, the dam break flood may not dissipate quickly and greater distances downstream may need to be considered, especially where there are buildings and other places of occupation at risk.

When carrying out dam break studies, other factors that must be included are:

- downstream hydraulic roughness
- other significant downstream hydraulic coefficients such as expansion and contraction coefficients
- dam break characteristics including breach base width, breach side slopes, breach depth, time for completion of breach
- spillway discharge rating curve
- storage versus height curves

- inflow hydrograph
- downstream tributary inflows.

The output from a dam break analysis must include:

- hydrograph at each section (flow versus time)
- depths at each section at appropriate time intervals
- velocities at each section at time intervals
- flood peak arrival times at each section
- the first rise in water level at each section
- recession time of the dam break flood.

This information needs to be summarised in tables and plotted on a map. The preferred map scale is 1 in 5000 with contours at maximum two metre intervals. However this can be varied depending on the scale of the inundated area.

It is expected that a detailed dam break analysis will provide results that are at best accurate to +/– 1m vertically. However, it should be noted that most dam break models are based on two-dimensional cross sections. Real life effects such as run-up around bends, the effects of rolling wave fronts and the effects of debris building up into secondary dams and then breaking may not be catered for in such models.

Details on dam breach mechanisms for comprehensive assessments are described in section 4.7.5.

4.7.5 Dam breach mechanisms for two-dimensional flow analyses and comprehensive assessments

Assumptions made of dam breach parameters can significantly affect the results of dam break analyses. The most significant parameters are the dimensions of the fully developed breach and the time it takes for the breach to develop.

Breach analyses must include sensitivity tests using assumed breach parameters to gauge their impact on the overall analysis.

The following procedure must be used for determining the magnitude of any potential dam breaches (Allen 1994). The same procedure is to be used for determining the ultimate size of the breach for both overtopping failures and for sunny day failures. In piping failures, it is to be assumed that the breach is initiated at the level which produces the maximum discharge from the breach. Unless special provisions are made, overtopping failures should be initiated as soon as the embankment is overtopped.

1. Examine the structure, or proposed structure, of the dam and obtain any available service histories, design reports or design reviews which may indicate likely modes and/or locations of breaches for that type of structure.
2. Consider all possible breach mechanisms, with a view to selecting the critical mechanism after running dam break inundation models for each alternative breach.

Then for embankment dams:

3. Calculate Breach Formation Factor for the assumed failure condition:

   $BFF = V_w * h$

   where

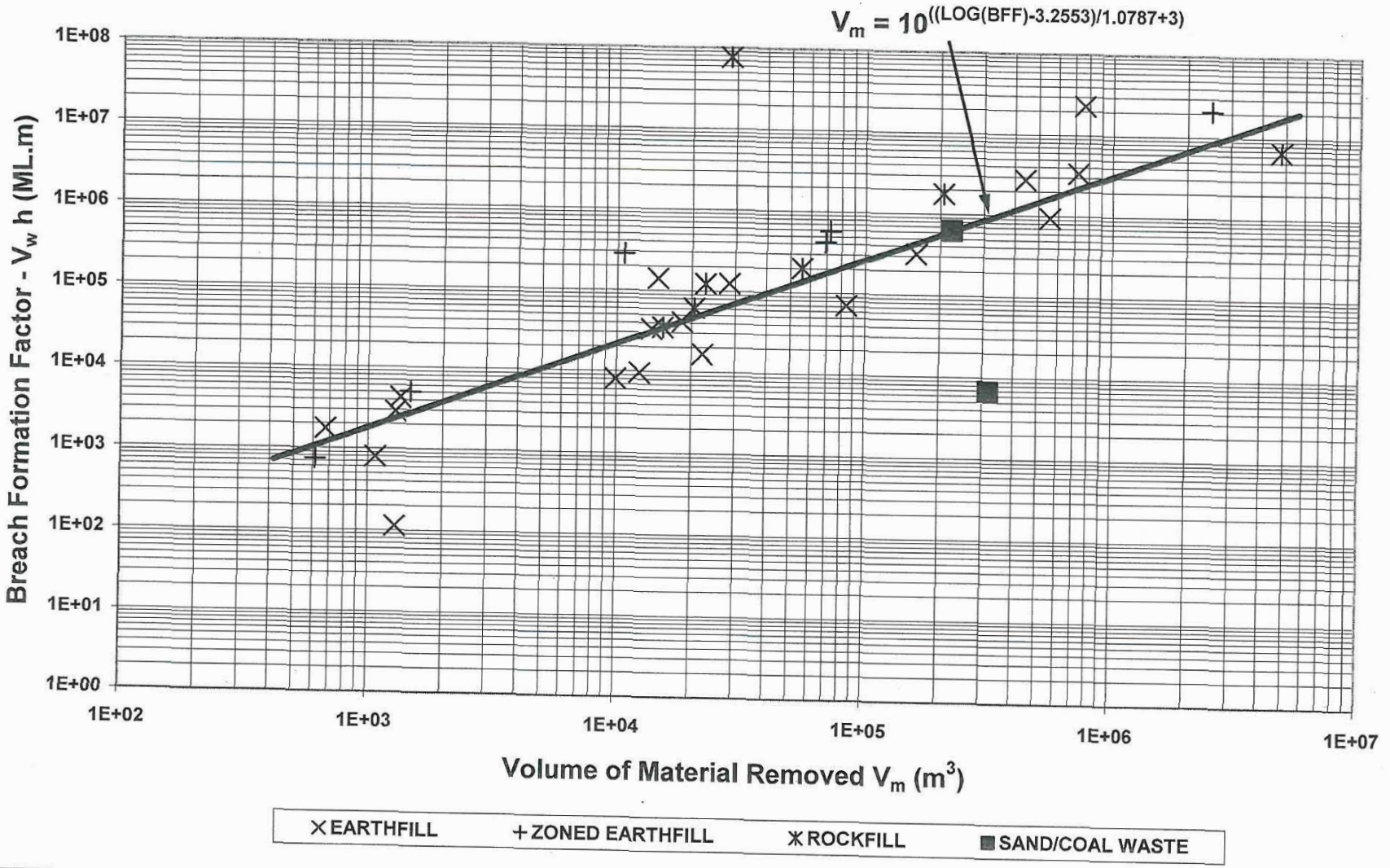
   BFF = Breach Formation Factor

   V_w = Total volume of water to flow through the breach (megalitres)

   h = Height differential between headwater and tailwater levels (metres)

4. Use Figure 4 to determine the volume of material expected to be removed during the formation of the breach V_m (cubic metres).

Figure 4—Outflow characteristics as a function of breach size



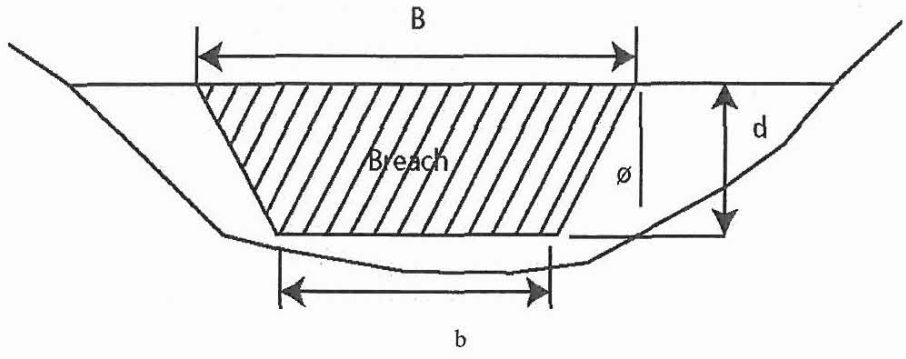
5. Determine the size of breach that corresponds to V_m assuming a trapezoidal breach with side slopes of between IH: IV and IH:2V. Note: If V_m is more than the volume of material available in the embankment, assume the embankment is effectively removed and replace V_m with this volume.
6. Unless special circumstances prevail (such as a very high embankment being required to store a relatively small volume of water), check to see that the breach size is within the following range of parameters (refer to Figure 5 below). That is,-

   $1.06 < B/b < 1.74$ with a mean of 1.29 and a standard deviation of 0.18

   $0.84 < B/d < 10.93$ with a mean of 3 and a standard deviation of 2.62

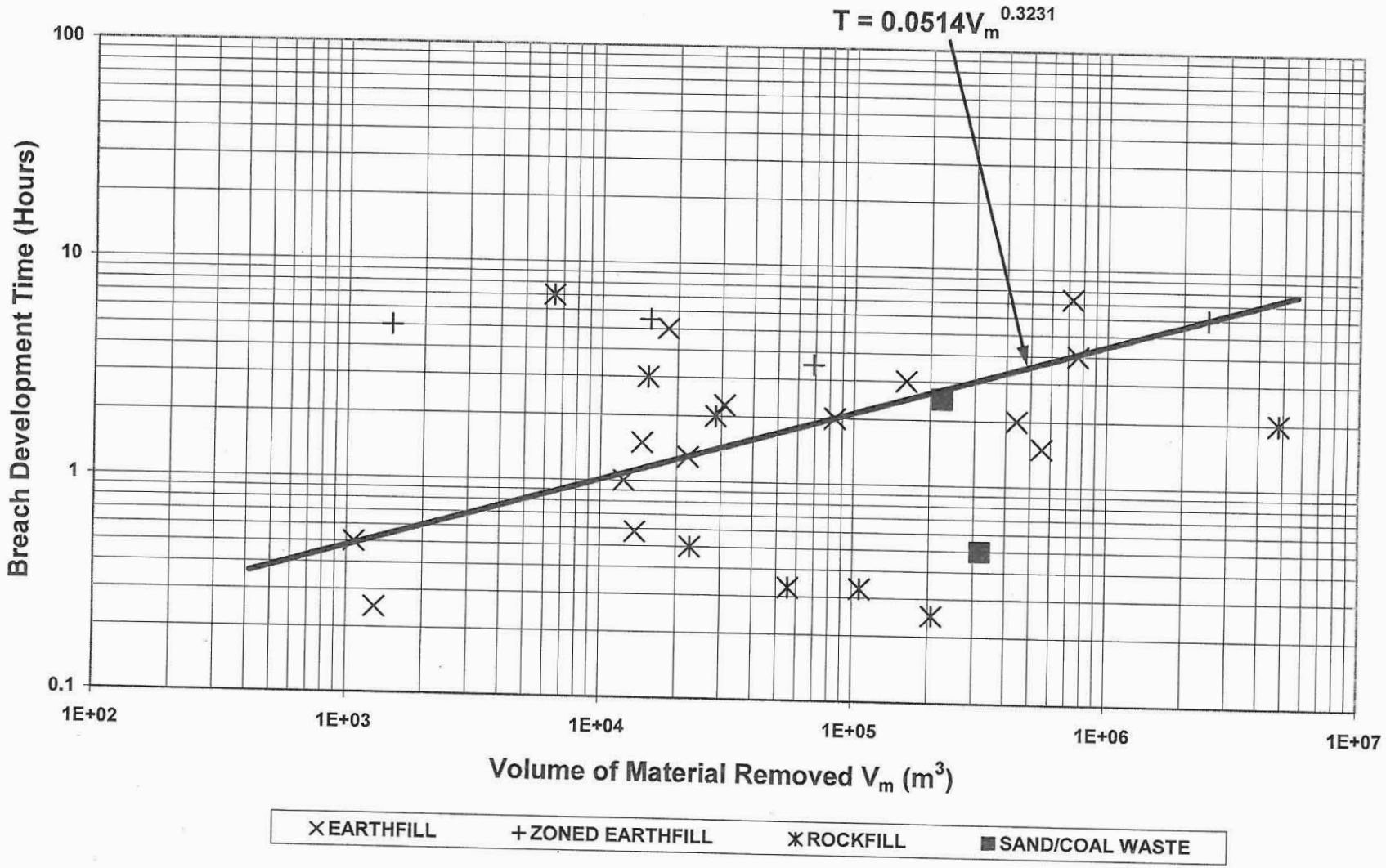
   side slope ø in the range 10° to 50° off vertical.

Figure 5—Notation for breach parameters



7. Use figure 6 to determine the breach development time.

Figure 6—Breach development time as a function of material removed



8. Run the dam break model and examine the hydraulic conditions occurring in the breach throughout the discharge and qualitatively modify the parameters accordingly. For example, if the breach outflow is heavily affected by tailwater, increase the breach development time or reduce the size of the breach to reflect the reduced erosive capacity of the flow. If the discharge continues at high levels long after the breach has been fully developed, increase the size of the breach.

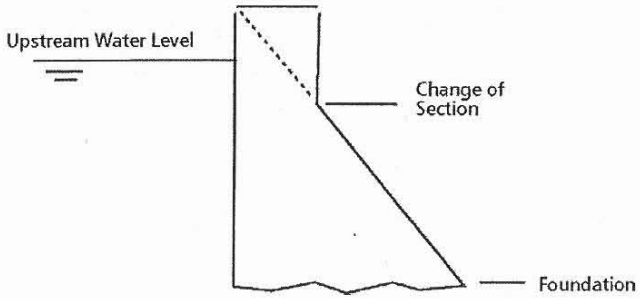
Note: Saddle dams are likely to fail relatively quicker and more completely than main embankment dams because they store more water for a given embankment volume.

9. Conduct a sensitivity analysis on the adopted parameters with due regard to the composition of the embankment.

And for Concrete dams:

10. Determine the storage level at which failure is likely to occur. If no design information is available, assume removal of the top of the non-overflow section above the change of section and the dam foundation. However, this assumption should be checked during model analysis, and, if a more critical case is identified, this should be adopted.
11. Assume that at least 30 per cent of the monoliths in the main section of a mass gravity structure are instantaneously removed at either the change of section or the dam foundation (refer to Figure 7 below).

Figure 7—Typical mass concrete dam cross-section



12. Assume complete removal of any arch dam or multiple arch dam as rapidly as the model will allow.
13. Conduct a sensitivity analysis on the adopted parameters.

4.7.6 Two or more dams on the same watercourse

Sometimes, two or more dams occur on the same watercourse. In such circumstances, it must be assumed that the failure of an upstream dam may trigger the failure of downstream dams. If the downstream dam cannot store the contents of the upstream dam without failure, the combined effect of multiple dam failures must be considered when determining the incremental population at risk for the upper dam for failure events. Similarly, if failure of a downstream dam could contribute to the failure of an upstream dam (such as through a rapid drawdown failure if headwaters of the downstream dam back up against the upstream dam), the potential failure of the upper dam must be considered when determining the incremental population at risk of the lower dam for failure events. The dam failure case producing the highest incremental population at risk must be used to determine the failure impact rating for the dam.

4.7.7 Other failure events

If the registered professional engineer considers that other failure events could result in a higher incremental population at risk, these failure conditions must be considered and described in the failure impact assessment. These failures may include:

- storage rim instability
- factors such as deterioration, old age, design or construction faults and poor maintenance
- damage due to fire, wind (for example, causing beaching leading to a breach) and escape of water into mining tunnels/shafts beneath reservoirs
- vandalism.

4.8 Periodic re-assessment of failure impact rating

Provided that:

- the records of the previous failure impact assessment still exist and
- there have not been substantial changes in:
    - the stream channel cross-sections and roughness
    - the embankment and spillway geometry and
    - the magnitude of the design floods

it is permissible for each consequential re-assessment of a failure impact rating (after the last failure impact rating has been accepted by the chief executive) to use the same inundation data as used in the previous analysis for assessment of the population at risk.

However, the population at risk must be re-calculated as part of each re-assessment of the failure impact rating.

In all other cases, reassessment will require a complete analysis following procedures outlined in these guidelines.

The registered professional engineer's certification must include justification of the approach adopted in the re-assessment.

5. Summary of failure impact assessment requirements

The following information is to be included in a written failure impact assessment:

Executive summary/introduction

A general description of the dam and a summary of the results of the failure impact assessment including:

- type of dam
- general location of the dam
- height and storage capacity of the dam
- the maximum population at risk
- a description of the critical failure event producing the maximum population at risk
- the recommended failure impact assessment category for the dam.

General information

- name of dam
- owner of dam (that is, individual or company)
- dam owner contact details (that is, postal address, street address, phone number, facsimile, email)
- status of dam (that is, existing or proposed dam or proposed work)
- property description of dam (for main part of dam wall including portion, parish, county and locality)
- location of dam (that is, longitude and latitude)
- date dam construction completed to current arrangement
- licence or development permit number (if any)
- date last failure impact assessment accepted by the chief executive
- date last failure impact assessment submitted to the chief executive
- attach relevant maps (including map number, scale, map date and height accuracy). Copies of inundation maps in electronic format are also desirable.
- attach copies of relevant aerial photographs (if any) (including photographic series name, film number, run number, approximate scale, date flown, photograph number(s))
- attach other topographic or cadastral source data (for example, detailed survey plans, orthographic maps, property boundary details)
- name of watercourse or offstream storage (including adopted middle thread distance (AMTD) measured in kilometres).

Catchment details

- catchment area (hectares)
- catchment general description
- percentage of catchment which has-
  - bare ground, rock, pavements, roofs, city areas (fully built)
  - rocky, clayey or non-absorbent soil with scanty herbage
  - open forest or grassed land, cereal crops
  - average grassed timberland of medium soil texture
  - heavily timbered country, closely cultivated land and pasture
  - sand
- average catchment slope.

Dam description

- type (that is, homogenous earthfill dam, zoned earth and rockfill dam, concrete dam or other)
- height (that is, the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the dam or, if the dam is not across a watercourse, between the lowest elevation of the outside limit of the dam and the top of the dam)
- total length of main dam (that is, metres from end of left abutment to end of right abutment)
- total length and brief description of other dam components (for example, saddle dams)
- saddle dam details
- purpose of storage (for example, water supply for irrigation)
- dam capacity to full supply level (in megalitres)
- dam surface area at Full Supply Level
- details of the storage capacity curve used in the analysis.

Spillway description

- type of spillway
- dimensions of spillway.

Data

- summary of the data collected for the analysis and an assessment of the appropriateness and accuracy of the data
- summary of the findings/verification of the site including details of who undertook the inspection and inspection date(s)
- spillway rating curve used in the analysis
- details of the critical flood used in the analysis and a summary of the methodology used to derive it.

Results and discussion

- analytical technique used (that is, two-dimensional flow analysis, simplified assessment or comprehensive assessment or a combination of these) and justification for use
- details of modelling used including-
  - model or models used in the analysis
  - breach parameters adopted and the basis for their adoption
  - hydrological inputs used
  - statement of calibration data used to validate the models generated
  - degree of extrapolation adopted
  - cross-sections used and roughness parameters adopted
  - predicted accuracy of the modelling, both in terms of flood levels and the population at risk
  - statement on the sensitivity of the model results to the various adopted parameters with supporting evidence drawn from the modelling undertaken.
- failure events considered
- reasonable upper and lower limits of population at risk as a result of the analysis
- recommended failure impact rating (that is, category 1 or 2 failure impact rating or not referable) and the critical dam failure condition determining this rating
- failure impact zone accounting for sufficient points of impact for all relevant failure events including map showing the extent of the failure impact zones (hard copy mandatory and electronic format desirable)
- incremental population at risk for all relevant failure events (including the nature of the site and justification for the populations used for places of occupation not listed in Appendix A)
- statement on the range of population at risk that can be reasonably expected for the critical case as a result of the analyses.
- detailed summary of the buildings and other places of occupation containing population at risk, and the location of this population
- details of dam break analyses
- commentary on sensitivity analyses.

Certifying registered professional engineer

- name
- registration number
- contact details (including postal address, street address, telephone number, facsimile, email as appropriate)
- statement that he or she is not the owner or operator, an employee of the owner or operator
- statement of certification (refer to section 3.2 for details of what is required in this statement)
- signature
- date.

6. Bibliography

6.1 References

Allen, P.H. (1994), Dam Break Breach Mechanisms, ANCOLD Bulletin No.97, August.

Wang, J.S., Ni., H.G. and He, Y.S. (2000), Finite Difference TVD Scheme for Computation of Dam Break Problems, Journal of Hydraulics Division ASCE, Volume 126 (4), April.

Zoppou, C and Roberts, S., (1999), Catastrophic Collapse of Water Supply Reservoirs in Urban Areas 1999, Journal of Hydraulics Division ASCE, Volume 125 (7), July.

Department of Environment and Resource Management (DERM) (2010), Guidelines on Acceptable Flood Capacity for Dams

6.2 Software

Standard commercial packages capable of determining inundated areas for two-dimensional flow include:

- MIKE 21—Danish Hydraulic Institute
- DELFT-FLS—Delft Hydraulics.

Standard commercial packages useful for dam break analysis include:

- BOSS FLOODWAV, NWS DAMBRK (Version 3.0)—International
- MIKE 11—Danish Hydraulics Institute
- RUBICON.

7. Appendices

7.1 Appendix A—Default populations

Nature of buildings or other places of occupation	Equivalent population
Detached housing [1]	2.9 per house
Semi-detached, row or terrace housing [1]	2.0 per house
Multi-unit buildings [1]	1.7 per unit
Blocks of flats [1]	1.7 per flat
House or flat attached to a shop, office, etc. [1]	2.5 per house or flat
Approved caravan parks [1,16]	1.8 per caravan site
Approved camping grounds [2,16]	0.45 per camping site
Hotel/motel accommodation [3]	1.0 per bedroom
Child care centres [4]	0.4 per child and staff member
Kindergartens, pre-schools [5]	0.25 per student and staff member
Primary schools (day) [5]	0.25 per student and staff member
High schools (day) [6]	0.3 per student and staff member
Tertiary education centres Lectures—day Lectures—evening	 0.35 per student and staff member attending during the day 0.15 per student and staff member attending during the night
Offices [8]	0.4 per employee
Restaurants [9]	0.3 per member of staff and diners' places
Medical centres [10]	1.7 per member of staff
Mines	Total of all personnel working in inundated area where the path to escape the inundation will be cut-off by the incoming flows.
Tavern/hotel bars [11]	0.15 per m^2 of patrons' area
Shops, shopping centres [12]	2.0 per 100 m^2 of gross area
Hospitals [13]	1.0 per bed plus 0.33 times the total number of staff
Institutional accommodation [14]	1.0 per bed plus 0.33 times the total number of staff
Service stations [15]	0.4 times the total number of staff
Industrial buildings and other non-residential sites	0.4 times the total number of staff
Department of Transport and Main Roads moorings	2.0 per mooring

Notes:

1. The occupancies for these dwellings are derived from the overall Queensland figures for persons, by dwelling structure and occupied dwelling structures, by tenure type (private dwellings) in the 1996 census.
2. This occupancy comes from an analysis of 1999 figures for the number of permits issued, the numbers of campers per permit and the duration of each permit for 20 camping grounds under the control of the Department. The average number of campers per permit was 3.0 and the average site occupancy rate was 14.5 per cent. Therefore an average occupancy value of 0.45 campers per site has been adopted.
3. This occupancy assumes that a hotel/motel bedroom will typically accommodate two people, who will be present for half of any one day, and that number of staff will compensate for the fact that generally not all rooms will be (fully) occupied.
4. This occupancy is based on a typical 9.5 hour day (8:00-5:30).
5. These occupancies are based on a typical 6 hour day (9:00-3:00).
6. This occupancy is based on a typical 7 hour day (8:30-3:30).
7. These occupancies are based on a typical 8 hour day (9:00-5:00) for day lectures and a typical 3 hour day (6:00-9:00) for evening lectures.
8. This occupancy is based on a typical 9 hour day (8:30-5:30).
9. This occupancy is based on the following assumed patronage:
    a. 10 per cent full—9:00 am—noon, 2:00 pm—6:30 pm
    b. full-noon—2:00 pm, 6:30 pm—10:30 pm
    c. staff numbers are 10 per cent of number of places.
10. This occupancy is based on a 10 hour day (8:00-6:00) and assumes 3 patients at the location for each doctor and other staff member.
11. This occupancy is based on the following assumed breakdown of daily patronage:
    a. 10 per cent of daily peak—10:00 am—noon
    b. daily peak—noon—2:00 pm
    c. 15 per cent of daily peak—2:00 pm—5:00 pm
    d. daily peak—5:00 pm—7:00 pm
    e. 50 per cent of daily peak—7:00 pm—8:00 pm
    f. 25 per cent of daily peak—8:00 pm—10:00 pm.

    The Liquor Licensing Division of the Department of Employment, Economic Development and Innovation cited maximum numbers of patrons as $2/m^2$ standing and $1/m^2$ dining. The occupancy rate is therefore based on an assumed annual average for the daily peak patronage of $0.6/m^2$ plus a 10 per cent allowance to cover staff.
12. This occupancy rate is an estimate based on information from the former Appendix B of Volume 1 of the Guidelines for Planning and Design of Sewerage schemes (issued by Department of Natural Resources) which has now been superceded by the DERM Planning Guidelines for Water Supply and Sewerage.
13. The occupancy rate of 1.0 per bed assumes that the number of visitors will compensate for the fact that generally not all beds will be occupied. The staff factor applies to the sum of the numbers of staff on different shifts.
14. These occupancies are identical to those for hospitals. It has been assumed that lower visitor numbers will offset the higher bed occupancy ratio for institutions.
15. This occupancy rate applies to the sum of the numbers of staff on different shifts. It contains a 20 per cent allowance to cover customers.
16. Only camping areas and caravan parks approved by government agencies (local, state or federal) or included in local authority planning schemes should be included. Because of the difficulties associated with determining the number of sites, and their permanence, of non-approved camping grounds and caravan parks, they are excluded from assessment.

7.2 Appendix B—Definitions

AMTD is adopted middle thread distance

Annual exceedance probability is the probability that a particular flood value will be exceeded in any one year.

Bed and banks for a watercourse or lake is the land over which the water within the watercourse or lake normally flows or the land normally covered by that water, whether permanently or intermittently. This does not include land adjoining or adjacent to the bed or banks that is, from time to time covered by floodwater.

Dam means:

1. (a) works that include a barrier, whether permanent or temporary, that does or could impound water; and
   (b) the storage area created by the works.
2. The term includes an embankment or other structure that controls the flow of water and is incidental to works mentioned in item 1(a).
3. The term does not include the following:
   (a) a rainwater tank
   (b) a water tank constructed of steel or concrete or a combination of steel and concrete
   (c) a water tank constructed of fibreglass, plastic or similar material.

Dam break flood is the flood event produced by a dam failure.

Dam crest flood is the flood event which, when routed through the storage with the storage initially at full supply level, results in a still water level in the storage, excluding wind and wave effects which:

- for an embankment dam, is the lowest point of the embankment crest
- for a concrete dam, is the level of the non-overflow section of the dam, excluding handrails and parapets if they do not store water against them
- for a concrete faced rockfill dam, is the lowest point of the crest structure.

Dam failure is the physical collapse of all or part of a dam or the uncontrolled release of any of its contents.

Development has the meaning given by the *Sustainable Planning Act 2009*, section 7. Development is any of the following–

a. carrying out building work
b. carrying out plumbing or drainage work
c. carrying out operational work
d. reconfiguring a lot
e. making a material change of use of premises.

Development permit is a development permit as defined under the *Sustainable Planning Act 2009*. A development permit authorises assessable development to take place:

a. to the extent stated in the permit; and
b. subject to:
   i. the conditions of the permit; and
   ii. any preliminary approval relating to the development the permit authorises, including any conditions of the preliminary approval.

Failure impact assessment is an assessment about the safety of a dam or proposed dam certified:

a. by a registered professional engineer who is not, for the dam, or the proposed dam
   i. the owner or
   ii. an employee of the owner or
   iii. the operator or
   iv. an employee of the operator and
b. in accordance with the Guidelines for Failure Impact Assessment of Water Dams issued by the chief executive.

Failure impact zone is the area affected by the failure of the dam. The zone is limited to the area where the incremental effect of a dam break flood is 300 mm or higher.

Full supply level is the level of the water surface of the dam when the water storage is at maximum operating level when not affected by flood.

Hazardous waste is any substance, whether liquid, solid or gaseous, derived by, or resulting from, the processing of minerals that tends to destroy life or impair or endanger health; or ash resulting from the process of power generation.

Height for a dam, the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the barrier or, if the barrier is not across a watercourse, between the lowest elevation of the outside limit of the barrier of the dam and the top of the barrier.

Height for a weir, barrage or dam, means the measurement of the difference in level between the natural bed of the watercourse at the downstream toe of the barrier or, if the barrier is not across a watercourse, between the lowest elevation of the outside limit of the barrier and the top of the barrier.

Incremental effect is the difference between flood impact that what would occur under a given set of conditions with no dam break and the flood impact under the same set of conditions with a dam failure.

Information notice is a formal notice of a decision made under the Act. The Act states when information notices must be sent. Information notices must state:

- the decision (Act requirement)
- the decision maker's findings on material questions of fact (section 27B *Acts Interpretation Act 1954* requirement)
- the evidence on which those findings were based (section 27B *Acts Interpretation Act 1954* requirement)
- the reasons for the decision (Act requirement)
- the name and address of any other person who was given the notice (Act requirement)
- that the person to whom the notice is given may appeal for an internal review of the decision within 30 business days after the notice is given (Act requirement)
- how to apply for an internal review (Act requirement).

Owner of land means any of the following, and includes the occupier of the land:

a. the registered proprietor of the land under the *Land Title Act 1994*

b. the lessee or licensee under the *Land Act 1994* of the land

c. the holder of a mineral development licence or mining lease over the land under the *Mineral Resources Act 1989*

d. the person or body of persons who, for the time being, has lawful control of the land, on trust or otherwise

e. the person who is entitled to receive the rents and profits of the land.

Owner of a referable dam means the owner of land on which the referable dam is constructed, or is to be constructed.

Population at risk is the number of persons, calculated using these guidelines, whose safety will be at risk if the dam, or the proposed dam after its construction, fails. For the purposes of this guideline, persons are considered to be at risk if they are within the failure impact zone.

Probable maximum flood is the flood resulting from probable maximum precipitation, and where applicable snow melt, coupled with the worst conditions that can be realistically expected in the prevailing meteorological conditions.

Probable maximum precipitation is the theoretical greatest depth of precipitation for a given duration that is, physically possible over a particular catchment area, based on generalised methods.

Referable dam is a dam or a proposed dam:

a. which must have a dam failure impact assessment carried out under the Act

b. for which the assessment states that the dam, or the proposed dam after its construction will have a category 1 or category 2 failure impact rating

c. for which the chief executive has, under section 349, accepted the assessment.

The following are not referable dams:

a. a hazardous waste dam

b. a weir, unless the weir has a variable flow control structure on the crest of the weir.

The following are not dams and cannot therefore be referable dams:

a. a rainwater tank

b. a water tank constructed of steel or concrete or a combination of steel and concrete

c. a water tank constructed of fibreglass, plastic or similar material.

Registered professional engineer is a registered professional engineer, a registered professional engineering company or a registered professional engineering unit as defined under the *Professional Engineers Act 2002*.

Ring tank is a dam that has a catchment area, that is, less than three times its maximum surface area at full supply.

Storage capacity means the capacity of water ordinarily stored in a thing.

Top of the barrier for a weir, barrage or dam, means the level of the top of the barrier exclusive of any parapet or ancillary structure or, if the barrier includes a spillway, the level of the top of the abutment walls adjoining the spillway exclusive of any parapet or ancillary structure.

Water means:

a. water in a watercourse, lake or spring

b. underground water

c. overland flow water

d. water that has been collected in a dam

e. includes any other liquid or a mixture that includes water or any other liquid or suspended solid.

Weir means a barrier constructed across a watercourse below the banks of the watercourse that hinders or obstructs the flow of water in the watercourse.

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Queensland
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Contents

1 Introduction

Currently, there are an estimated 300 referable dams in Queensland. These dams fulfil an important role in our society including water supply, hydroelectric power generation, process water management, flood control, sediment and water control and recreation.

The failure of these dams can have significant consequences ranging from loss of life or injury to economic loss and damage to property and the environment. Queensland has had a good dam safety record. However, continuing incidences of dam failures around the world highlight the need and importance of dam safety management programs.

In Queensland, under the *Water Act 2000* and common law, responsibility for the safety of a dam rests with the dam owner. Dam owners may be liable for loss and damage caused by the failure of a dam or the escape of water from a dam. Consequently, dam owners need to be committed to dam safety and have an effective dam safety management program. A dam safety management program is intended to minimise the risk of a dam failing and to protect life and property from the effects of such a failure should one occur.

1.1 Purpose

The aim of this guideline is to describe practices dealing with the construction and management of referable dams and assist dam owners to safely manage their dams and protect the community from dam failure.

It is to be used by:

- owners of referable dams
- operators of referable dams
- employees of referable dam owners and operators
- consultants for referable dam owners and operators.

This guideline outlines best practice in dam safety and is primarily advisory in nature. However, development permit conditions imposed on individual dams under the provisions of the *Water Act 2000* and the *Integrated Planning Act 1997*, may "call up" or reference relevant sections of these guidelines as a way of undertaking particular activities (eg preparing an emergency action plan). To assist users of these guidelines a brief overview of Queensland's regulatory arrangements for referable water dams is given in section 3.

1.2 Scope

This guideline has been developed specifically for referable dams. However, it may be used by owners of dams which are not referable to develop a dam safety management program.

1.2.1 What is a referable dam?

A dam is referable if:

- a failure impact assessment is required to be carried out under the *Water Act 2000*, and
- that assessment states that the dam has or will have a Category 1 or Category 2 failure impact rating. And
- the chief executive has, under the Water Act 2000, accepted the assessment.

In addition, some dams may be made referable by:

- a regulation made under the *Water Act 2000*, or
- the transitional provisions in the *Water Act 2000*.

A failure impact assessment is required when a dam is or will be:

- more than 8 metres in height and have a storage capacity of more than 500 megalitres or
- more than 8 metres in height and have a storage capacity of more than 250 megalitres, and a catchment area that is more than 3 times the surface area of the dam at full supply level.

Additionally, the chief executive may give a dam owner a notice to have a dam failure impact assessed (regardless of its size), if the chief executive reasonably believes the dam will have, a Category 1 or Category 2 failure impact rating.

Referable dams are classified according to categories which are based on the population at risk if the dam fails.

Dams with a Category 1 failure impact rating have between 2 and 100 people at risk.

Dams with a Category 2 failure impact rating have over 100 people at risk.

If less than 2 people are at risk by the dam failing then the dam is not referable under the *Water Act 2000*.

The following are also not referable dams under the *Water Act 2000*:

- a dam containing, or a proposed dam that after its construction will contain, hazardous waste
- a weir, unless the weir has a variable flow control structure on its crest.

The following are not dams under the *Water Act 2000* and therefore cannot be referable dams:

- a rainwater tank
- a water tank constructed of steel or concrete or a combination of steel and concrete
- a water tank constructed of fibreglass plastic or similar material.

The Guidelines for Failure Impact Assessments of Water Dams published by the Department of Natural Resources and Mines (NR&M) provide additional information on undertaking a failure impact assessment to determine the population at risk for a dam.

1.2.2 Replacing old guidelines

This guideline comes into force with the commencement of the dam safety provisions of the *Water Act 2000*. This guideline replaces the 1994 guidelines known as the Queensland Dam Safety Management Guidelines 1994.

2 What is a Dam Safety Management Program?

A dam safety management program is a system that incorporates dam safety values as part of the culture of the organisation and the day-to-day operation of a referable dam. A dam safety management program comprises policies, procedures and investigations which minimises the risk of dam failure.

A dam safety management program includes:

- site investigation
- design
- construction
- operation and maintenance
- surveillance
- remedial action and modification
- abandonment and removal of dams.

Its benefits are that the:

- owner is aware that the dam complies with current engineering standards for safety
- owner is assured that the dam is operated in a safe manner
- owner has the condition of the dam assessed on a regular basis
- owner is prepared for an emergency situation at the dam
- risk of dam failure is minimised.

2.1 Documentation for a safety management program

A dam safety management program should ultimately result in six levels of documentation being available for each dam. These are:

1. Investigation, Design, and Construction Documentation including Data Book, Design Report and As-Constructed Details (or Construction Report)[1]
2. Standing Operating Procedures (SOPs)
3. Detailed Operating and Maintenance Manuals (DOMMs)
4. Inspection and Evaluation Reports
5. Dam Safety Review Report [2]
6. Emergency Action Plan (EAP).

Dam owners should securely store these documents.

Dam owners should ensure that each of the levels of documentation is identified for inspection and auditing purposes. The documentation could either be combined into a single document or left as groups of documents.

Details on the preparation of these documents and issues to be addressed are outlined in the following sections of this guideline.

1 Where appropriate. For example, the As-Constructed Details (or Construction Report) and Design Report for an older dam may not have been prepared or retained.

2 Where appropriate. For example, a new dam is unlikely to have had a safety review as these are generally undertaken every 20 years.

2.2 Training of personnel engaged in dam safety

Dam owners should ensure personnel engaged in dam safety related investigations and studies have adequate experience and training relevant to the type of dam and the facilities being managed.

Dam owners should ensure that the operating personnel involved in the day-to-day dam safety activities (as outlined in SOPs and EAPs) are experienced and/ or trained in aspects of operation of the owners dam.

Dam Owners should develop a program for keeping the skills of their dam operation staff up to date through training programs, courses and 'on the job' training.

2.3 Quality management of dam safety management programs

The Australian Standard for Quality Systems AS/NZS ISO 9001-3:1994 (Lam) [Quality Systems - Model for quality assurance in design, development, production, installation and servicing] can be used as a model for the quality assurance required for dam safety.

Developing and maintaining comprehensive documentation for a dam safety management program as described in these guidelines and quality management audits provide elements of a quality management system. Audit points should be identified within the dam safety management program to allow measurement of the effectiveness of the program and its components.

The dam owner, an internal auditor or a third party should conduct quality management audits on a systematic basis. When an internal auditor is used, it may be necessary to establish a management structure in which the dam safety functions are independent of the dam operator.

A quality management audit of documentation should establish:

- adequacy of the policies and the dam safety management program as a whole (systems audit)
- adequacy of the process and the necessary studies used to establish the documentation (process audit)
- adequacy of specific procedures, documentation or a specific investigation (validation audit).

Some of the specific issues, which should be examined in a quality management audit, include:

- the authority for performing activities
- allocation of responsibilities for particular activities
- actions to be undertaken and circumstances for such action.

3 Regulation of Referable Dams

Dam safety of referable dams is regulated to protect the community from dam failure. The chief executive of the Department of Natural Resources and Mines (NR&M) is responsible for regulating referable dams. Dams are regulated by the chief executive through:

- safety conditions imposed on referable dams under the *Water Act 2000* (which are partly based on the failure impact rating of the dam)
- development permits containing conditions imposed under the *Integrated Planning Act 1997*, issued to approve the development of a dam (which are partly based on the failure impact rating of the dam)
- auditing of compliance with dam safety conditions (ie safety conditions imposed under the *Water Act 2000* and development permit conditions imposed under the *Integrated Planning Act 1997*)
- emergency action provisions contained in the *Water Act 2000*.

3.1 Development permits

3.1.1 General

Dam safety conditions attach to development permits and incorporate requirements specific to each individual dam. The safety conditions must be relevant to, but not an unreasonable imposition on, the dam or reasonably required for the dam. Dam owners can appeal against dam safety conditions imposed or changed by the chief executive.

Part of the intention of these conditions is to ensure a dam owner develops a dam safety management program for their dam. These guidelines provide advice on how to develop a dam safety management program. Dam safety conditions may require a dam owner to develop specific plans, procedures and reports that will form part of the dam safety management program. If the specific plans, procedures and reports have already been developed by the dam owner (in accordance with these guidelines), those documents will generally be cited in the conditions for that dam.

For example, each dam will generally be issued with a dam safety condition dealing with Emergency Action Plans. Where a dam already has an Emergency Action Plan, the condition might state:

The current Emergency Action Plan for the dam is Document XX as updated from time to time.

The dam owner must provide one copy of the current Emergency Action Plan to the Chief Executive, Department of Natural Resources and Mines by date.

The contact details contained in the Emergency Action Plan must be reviewed prior to DATE each year.

The Emergency Action Plan must be reviewed at least every five years from (date).

The dam owner must ensure that the current (and changed?) Emergency Action Plan is provided to the following parties

- *Specific local government(s) eg Esk Shire Council*
- *Local counter disaster agencies affected by emergency events .eg Ipswich Counter Disaster Coordination Committee*
- *NR&M - Dam Safety*

- *Any additional group specific to this dam*

In all emergencies, the dam owner must respond in accordance with the Emergency Action Plan.

In the event of an emergency, the dam owner must also, within 7 days of the event, prepare an Emergency Event Report and provide a copy of the report to the Department of Natural Resources and Mines. .

The Emergency Event Report must contain:

- *a description of the event;*
- *instrumentation readings (where appropriate);*
- *description of any observed damage;*
- *photographs;*
- *details of communication which took place during the emergency; and*
- *comment on the adequacy of the EAP*
- *any recommendations or suggested changes to the EAP.*

3.1.2 New Dams and Works that Increase Storage Capacity

A development permit is an approval under the *Integrated Planning Act 1997* which allows "assessable development" to occur according to conditions stated in the permit. The construction of a new referable dam and carrying out work that will increase the storage capacity of a referable dam by more than 10% is "assessable development". The chief executive has the power under *Integrated Planning Act 1997,* to impose and change dam safety conditions on development permits issued approving these types of development.

A development permit will attach to the land where the referable dam is located. This means it will bind:

- the current owner of the land
- future owners of that land
- any occupier of that land (eg a tenant).

A person wanting to construct a new referable dam under the *Water Act 2000* must apply for and obtain a development permit before starting construction. A dam owner must also obtain a development permit to carry out works that will increase the storage capacity of a referable dam by more than 10%, before that work commences. The *Water Act 2000* requires a development application for these types of assessable development to be supported by evidence that the chief executive has accepted a failure impact assessment of the dam.

Prior to submission of a development application, owners and their consultants should consult with officers of the Dam Safety Group in NR&M to discuss technical details of the development and potential dam safety conditions. The Dam Safety Group provides advice to the chief executive on dam safety conditions to be attached to development permits. Dam owners should ensure that they use relevant guidelines prepared by the chief executive when designing and constructing their dam.

Prior to construction of any referable dam, the chief executive will overview each proposal and may require changes to be made to the proposal prior to granting a dam development permit. Where conflicts of opinion exist, the chief executive may seek advice from independent experts before making a decision.

3.1.3 Development Permits for Existing dams

For existing licenced dams which are referable under the *Water Act 2000* the previous licences for the dams will be taken to be a development permit[3] which has dam safety conditions attached. Dam safety conditions applied to this development permit for existing licenced dams will therefore initially originate from the dam's waterworks license under the *Water Resources Act 1989* (Qld). The chief executive also has the power under the *Water Act 2000* to impose and change additional safety conditions on the dams.

These safety conditions are taken to be development permit conditions for the purposes of enforcement.

For existing unlicenced dams, which are referable under the *Water Act 2000*, the chief executive will develop and apply safety conditions under the *Water Act 2000*.

The chief executive also has the power to change those safety conditions if satisfied changes should be made in the interests of dam safety. The safety conditions are taken to be development permit conditions for the purpose of enforcement.

3.2 Auditing

The chief executive, to identify shortfalls in a dam safety management program and areas of non-compliance, may carry out audits of compliance with development permit conditions.

There are two Acts in Queensland which deal with enforcement of dam safety. The *Water Act 2000* contains provisions to enable the chief executive to issue a compliance notice if that Act is contravened (eg fail to carry out a failure impact assessment when one is required). Additionally, as dam safety conditions are development permit conditions for the purpose of enforcement , penalties apply under the *Integrated Planning Act 1997* (Qld) for failing to comply with a development permit condition.

3.3 Emergency action provisions

The chief executive has the power to issue a direction to take emergency action under s.494 of the *Water Act 2000*. This notice is only issued if the chief executive is satisfied or reasonably believes that:

- there is a danger of the failure of the referable dam and
- action is necessary to prevent or minimise the impact of the failure.

If a person fails to comply with a notice without a reasonable excuse, action may be taken. The compliance provisions of the *Water Act 2000* will allow any person to bring an enforcement order proceeding in the District Court and seek a Court order forcing a person to comply with the notice.

In addition, the chief executive has power under the *Water Act 2000* to act to prevent or minimise the impact of a dam failure, if a notice is not complied with. The chief executive can recover any reasonable expenses incurred when taking such action and may also make the expenses incurred a charge on the land.

Emergency action notices also attach to the land where the referable dam is located, binding the owner of the land at the time it is issued and any future owners.

3 Defined under the Integrated Planning Act 1997.

4 Investigation, Design and Construction

4.1 Introduction

Dams engineering is not an exact science as it frequently involves uncertainties beyond prevailing knowledge. It relies heavily on mathematical principles, physical laws, experienced judgement and known safe practices.

Dam safety management requires that critical uncertainties are recognised, investigated and resolved to acceptable risk levels. Consequently, the investigation, design and construction phase of dams engineering plays an important role in dam safety.

At time of writing philosophies of risk assessment and management were starting to influence the design, management and operation of water dams throughout Australia. This guideline embraces those philosophies as far as they have been incorporated in published ANCOLD Guidelines. Dam owners are encouraged to utilise those philosophies to develop management and operation programs. However, this guideline will await broader dam community assessment of the methodologies before incorporating risk management as a recommended approach to management.

4.2 Issues concerning the dam owner

No two dams are the same. There are many issues including safety issues, which a dam owner should consider when developing a dam. Issues that are specific to dam safety include:

- the failure impact rating of the dam (that is whether the dam will have a Category 1 or Category 2 failure impact rating)
- the resources required to adequately address the technical issues associated with the investigation, design and construction of a dam
- the resources required to adequately manage the dam in a safe manner
- dam safety statutory requirements
- the consequences of potential dam failure.

Other issues, while possibly having dam safety implications, are primarily asset ownership issues. These include:

- environmental or downstream impacts which need to be considered
- the economic viability of the dam
- long-term maintenance management implications of dam ownership.

4.3 Consequence assessment

The regulation of referable dams under the *Water Act 2000* is based solely on the population at risk in the event of a dam failure. However, dam designers, on behalf of dam owners, may also wish to consider other potential consequences to determine design standards for a dam. These other consequences may include:

- economic loss of the asset
- commercial losses and social impacts
- impacts due to loss of water supply
- damage to property and infrastructure
- environmental damage.

If the owner wishes to take these factors into account he or she could undertake an assessment of the consequences of dam failure. A methodology for undertaking a consequence assessment can be found in the Australian National Committee on Large Dams (ANCOLD) Guidelines on the Assessment of the Consequences of Dam Failure.

The effort and resources a dam owner should put into a dam safety management program and the scope of the program is related to the consequences of the failure of a dam on life and property, as well as the complexity and novelty of the dam.

Some of the more common scenarios to be considered in consequence assessments include:

- dam break - the uncontrolled release of pondage for 'sunny day' conditions and a range of flood events
- remote floods - flood surges well downstream of dam which can coincide with storage release
- upstream floods - backwater effects of the dam during floods
- water supply loss - failure of pumps, outlet facilities, reservoir pollution etc
- operational problems - accidental opening of flood gates, equipment malfunction etc.

A consequence assessment should provide a profile of the potential damage of dam failure. In cases where failure does not impact on population and is of economic consequence only to the owner, a case may exist for a minimal dam safety management program. In contrast, where the potential for substantial damage costs exist and significant impact on others is likely, dam safety management should be more rigorous.

Dam owners should periodically review the consequence assessment to monitor any change in circumstances such as development downstream. Such developments can make non-referrable dams 'referable' and can cause changes to the required design standards.

4.4 Investigation

Many investigations are undertaken when developing a dam. Most focus on comparing alternate sites and determining the viability of a particular site, rather than focussing on dam safety issues. Examples of these investigations include:

- economic assessment of a dam, including water pricing studies
- land use studies
- impact assessment studies, including social, cultural heritage, and environmental studies.

Two areas of investigation predominantly relate to dam safety issues. These are:

4.4.1 Geological and geotechnical investigations

These include geological and geotechnical assessments of the site and materials. They are generally carried out in stages ranging from broad scoping levels to more detailed investigations depending on the findings of each stage. Each stage should be thoroughly planned to ensure that all matters, which may affect dam safety, are identified, investigated and appropriately resolved by the designer.

Investigations should not be limited to the dam site alone. The geology, topography and the depth of water held in the storage area should be considered. This ensures that major leakages, slope instabilities and significant reservoir-induced seismic activities, which may jeopardise the safety of the dam, are considered in the design.

All work undertaken in the geological and geotechnical investigation stage should be properly recorded and presented in a comprehensive report. This will enable the designer to define the extent of any further work required prior to finalising the design. Investigations are generally on going through the construction period as the foundations become fully exposed or the extent of any foundation work, such as grouting, is recognised. Consequently, investigative reports need to be updated and amended as construction proceeds. When construction is complete, a full and comprehensive report should be available as a reference for on-going surveillance of the dam and subsequent safety reviews.

4.4.2 Hydrological investigations

A suite of hydrological investigations should be undertaken to develop dam safety data for the proposed dam. These hydrological investigations, which are independent of yield hydrology[4], involve:

- developing an appropriate run-off model for the catchment
- calibrating this run-off model with historical flood data where possible
- assessing any operating limitations and criteria, which are to apply to spillway discharges
- assessing the consequences of potential failure of the dam:
  - particularly the population at risk - see NR&M Guidelines for Failure Impact Assessment of Water Dams
  - for best practice purposes to determine other consequences of failure (eg economic and environmental costs) using the ANCOLD Guidelines on Assessment of the Consequences of a Dam Failure (May 2000) if appropriate
  - determining the spillway design standard, spillway design flood and, if the spillway is a gated structure, determining any operating rules which are to be applied.

All work (including documentation of mathematical models) undertaken in hydrological investigations should be properly documented and presented in a comprehensive report. This will enable the designer to finalise the design and will assist subsequent reviews of this aspect of the design.

4 Yield hydrology is a major issue for the dam owner but has minor significance to dam safety.

4.5 Design

4.5.1 General

Factors which should be considered during the design of a dam, include:

1. Physical characteristics

- dam type
- location and alignment
- size and shape
- appurtenant works.

2. Geotechnical information

- material properties and availability
- foundation properties and treatment
- geological characteristics
- seismic loadings.

3. Hydraulic aspects

- type of spillway, means of flow control and energy dissipation
- hydrological characteristics
- hydraulic design and water loadings
- stream diversion requirements
- flood mitigation capacity.

4. Stability

- structural capacity of principle elements

5. Construction methods and sequencing

- including watercourse diversion requirements during construction

6. Operational aspects

- operational complexity and reliability
- requirements for ongoing monitoring
- technical capability and availability of operations personnel.

7. Environmental aspects

- environmental impacts including the effects of storage and barriers
- effect on upstream and downstream areas
- magnitude of downstream releases.

4.5.2 Specific Design Requirements

While the way in which these aspects are applied to a particular dam depends on its dam failure impact rating, size, importance, complexity and consequences of a dam failure, the key principles are:

- all dams structures should be designed to suit the loads to be applied to them in accordance with:
  - ANCOLD guidelines
  - relevant Australian Standards
  - notices (compliance and information) issued from time to time by the chief executive
  - generally accepted engineering practices

- in particular, dams must be able to withstand seismic loadings, flood loadings, normal operating loadings, construction loadings, post construction loadings.
- the regional and site geology must be understood and engineering geology models developed to form the basis for design
- the foundations must be capable of supporting the dam structure and controlling seepage
- the reservoir basin and rim must be sufficiently impermeable to prevent excessive losses of water (Any seepage must be controlled and instability must not occur at any stage of reservoir operation.)
- construction materials must be identified to meet site and design requirements
- the spillway size must be established on the basis of accepted engineering standards–ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams, 2000 (Hydrological and meteorological information used in the design must be appropriate for the dam locality and dam use)
- the cut-off design must be established on the basis of the loadings, strength of the available materials and the need to control the seepage (For embankment dams, the designer must incorporate adequate lines of defence including properly designed drains and properly designed filters to ensure the long-term integrity of the seepage control system)
- the outlet works must meet the requirements for the reservoir operation and must have provisions for safe operation and maintenance
- provision must be made for the long-term monitoring of the structural performance of the dam and its components
- an appropriate dam safety management program must be developed and adhered to through the investigation, design and construction processes to ensure all matters are properly attended to and adequately recorded.

Some of these factors may have a direct impact on dam safety, while others may have an indirect impact. The dam designer should be a registered professional engineer, highly experienced and with a good knowledge and understanding of dams. In some cases, dam owners may want to establish a review board of experts to provide guidance on the design of the dam. For large projects, dam owners may wish to engage a project design engineer who is assigned technical coordination responsibility for the dam during its design and construction.

These factors influence the construction cost of a dam. The designer should develop a design, which meets accepted safety standards and the needs of the owner (including budget). The designer should be aware of new technology and methods being adopted elsewhere, which may provide cost savings. Such savings should be critically evaluated in terms of possible long-term costs, which may occur should safety and operational problems be experienced with the dam. The more that is known about the site conditions and foundation materials the less conservative the design has to be, resulting in lower construction costs.

The designer should establish specific onsite construction and operational inspection programs for review by appropriate design personnel and technical specialists. These programs should include frequent inspections during construction to confirm that site conditions conform to those assumed for design or to determine if design changes may be required to suit the actual conditions. A major requirement is inspection and approval by the dam designer of the dam foundation and foundation treatment before the placing of dam materials. The final design inspection of the construction should include a complete review of the surveillance undertaken and testing of any operating equipment.

The designer should determine surveillance requirements for the dam including:

- inspections - operational design inspections should continue throughout the life of the project, in accordance with a formal inspection program covering all project features. The inspection program should meet the regulatory requirements specified in the dam safety conditions in the development permit

- instrumentation - as part of the surveillance requirements, there may be a need for instrumentation (eg settlement and foundation pressure). The designer should identify the need for, and position of instrumentation and include a schedule for timely reading, collecting, reducing, and interpreting the data. The design should include an advance determination of critical instrument observations or rates of data change and a plan of action if observations indicate a critical condition may occur. These critical instrumentation figures should be based on the design assumptions.

4.6 Construction

The supervising constructing engineer(s) should be experienced in dams engineering and be able to detect when variations to specified procedures are necessary, or when special attention is required in relation to:

- foundation treatment
- material selection and placement
- material manufacture (eg filters)
- material testing
- stream diversion
- concrete manufacture
- construction equipment selection
- other issues which can affect the safety of the dam.

The constructing engineer should have:

- a comprehensive understanding of the design
- responsibility for technical coordination between design and construction engineers
- responsibility for managing the construction staff to assure compliance with specifications.

One of the most important aspects of dam construction is the foundation inspection. It is seldom possible to fully identify all the characteristics of the foundations of a dam during the investigation stage. Once the foundations have been fully exposed and prepared, there may be a need to amend the design requirements. Inspections by the designer are necessary to confirm any amendments. If unanticipated conditions such as geological features are encountered, the designer must be involved in determining appropriate design changes.

Regular site visits and inspections by the designer and review engineers (where appropriate) are recommended.

4.7 Design and construction documentation

4.7.1 Data Book

Dam owners should compile and maintain a Data Book. A Data Book is a convenient source of information summarising all pertinent records and history. It should encompass the documentation of investigation, design, construction, operation, maintenance, surveillance, remedial action as well as monitoring measurements. A Data Book may be large and consist of several documents eg drawings, electronic data files and printed reports or smaller depending on the type and complexity of the dam.

4.7.1.1 Data Book Checklist

Data Books should include the following information:

General

Table of Contents

Background Information

- Statistical Summary of the main features of the dam
- Aerial Photograph of the Dam (if available)
- Historical Events (prior to construction, during construction and subsequent operation)
- Record of incidents at the dam
- Relevant Correspondence

Geological Information

- Regional Information
- Site Information
- Seismicity
- Relevant Correspondence

Hydrologic Information

- Design Floods
- Current Inflow Design Flood
- Relevant Correspondence
- Failure Impact Assessment
- Consequence Assessment

Foundation Information

- Description
- Design and Analysis
- Treatments
- Construction Records, Changes, and Modifications
- Instrumentation
- Known deficiencies (eg seepage, etc)
- Relevant Correspondence

Dam Structure

- Description
- Design and Analysis
- Treatments
- Construction Materials
- Construction records, changes, and modifications
- Instrumentation
- Deficiencies (eg cracking, etc)
- Relevant Correspondence
- as constructed drawings

Other Features -Spillway, Outlet Works, Mechanical Systems

- Description
- Design and Analysis
- Details of relevant control systems and operating principles
- as constructed drawings

4.7.2 Design Report

On most projects, a Design Report should be compiled once the design and construction stages are completed. However, on major projects, this may have to be staged. The designer should document the design and construction of the dam including:

- Designer's Operating Criteria (DOC), eg gate operating rules and cone valve operation protocols
- design parameters adopted and assumptions made (and their bases)
- methods of analyses
- results of analyses and investigations (numerical and physical)
- hydraulic model testing of final spillway arrangements
- complete set of drawings and specifications
- summary of As-Constructed documentation and other construction information (see 4.7.3).

The Design Report must contain sufficient information so that in the event of any safety problems relating to the dam, information can be quickly and easily obtained to resolve the problem.

When preparing a design report, the designer should consult the checklist of dam technology issues included as Appendix 3 - Checklist of Dam Technology Issues.

4.7.3 As-Constructed documentation

The constructing engineer should provide a complete record of the construction to assist in determining solutions to any safety problem, which may arise during the life of the dam. As a minimum, this record should include:

- decisions to adapt the design to actual field conditions
- as-constructed drawings indicating the actual lines, levels and dimensions to which the structure is built
- construction processes
- systematically compiled and comprehensive photographs and, where appropriate, videos of the construction, with particular coverage of significant events which include:
  - foundation treatment
  - material preparation and placement
  - filters, cut-offs
  - core materials
  - joint preparation
- foundation surface mapping of rock defects
- material test results and comparison with assumed design parameters
- instrumentation data including precise instrument locations and initial instrument readings
- construction inspection reports.

The As-Constructed documentation should be summarised and either incorporated into the Design Report or produced as a separate Construction Report.

5 Operations and Maintenance

5.1 Introduction

Proper operation and maintenance is essential for the continued viability and safety of a dam and its associated structures. Improper operation of a dam may result in dam failure, and poor maintenance can result in abnormal deterioration of the dam, reduced life expectancy of the dam and increase the possibility of dam failure.

Dam owners should have in place an operation and maintenance program, which is described by the following documentation:

- Standing Operating Procedures
- Detailed Operating and Maintenance Manuals
- Recording and Work Assignment system.

5.2 Standing Operating Procedures

Dams are normally designed to operate within a range of operating criteria. A good dam safety management program will ensure that:

- these operating criteria are known
- the dam is operated within these criteria
- the dam is maintained so that it can perform within the established criteria.

This should be done through Standard Operating Procedures (SOPs). These procedures should:

- define responsibilities for actions critical to the safety of the dam
- identify procedures for particular daily activities, which ensure that these activities are done safely, in the same way each time and in accordance with development permit conditions
- ensure appropriate people are notified when unforseen or unusual events occur.

Dam owners should ensure they operate their dam in accordance with the SOPs.

SOPs are beneficial as they provide information on procedures for a dam (including responsibilities and timings). They help to:

- ensure long term adherence to operating procedures and across changes in ownership and operating personnel
- ensure that a task is completed in the correct, repeatable manner. They reduce the probability of dam threatening situations by providing operating protocols for personnel to follow. Examples of situations, which may be avoided by using appropriate SOPs, include:
  - 'out of date' procedures being applied to activities such that the dam is not operated in the manner expected by others
  - problems not being fixed because dam safety inspections are not performed or are not carried out by appropriate people
  - critical equipment not being checked so that it is not operational when needed
  - the incorrect operation of flood mitigation dams which may result in decreased flood mitigation capability or the amplification or extension of flooding
  - failure to open gated spillways at the appropriate time, which can cause overtopping of the gates and subsequent failure of the dam
  - failure to close gated spillways or outlet works which may empty a reservoir.

SOPs provide documentation of the way in which various tasks are performed and provide a permanent record of actions taken to operate the dam. If action results in an undesirable outcome, SOPs may assist in determining the reason and amendments can be made to the SOP. SOPs enable reviews of an organisation's operations to improve efficiency.

Dam owners should develop SOPs for their dam and operate the dam in accordance with these SOPs. This guideline concentrates on those SOPs, which deal with dam safety issues such as:

- personnel training and procedural issues
- emergency action and incident reporting
- critical operating procedures
- monitoring and surveillance.

When developing SOPs, a dam owner should consider issues, which may affect the complexity of the SOPs including:

- the complexity of dam operations (The more complex the operation is, the more detailed and comprehensive the SOPs should be. For example, detailed SOPs will be required for a dam with a spillway, which is controlled by large, high capacity gates, which could release damaging flood flows downstream in the event of maloperation.)
- degree of backup required
- complexity of spillway arrangements
- simplicity of flow release regimes.

The location of SOPs is critical to their effectiveness. At least one copy of the SOPs should be located where dam operations are controlled and operational decisions are made. This is particularly important for structures with variable flow control.

In addition, to ensure that SOPs remain effective over time, dam owners should ensure each SOP is reviewed annually.

5.2.1 Developing SOPs

There are a number of tests that can be applied to determine whether a SOP needs to be developed for a task. Before writing a procedure for a task, you should consider what the consequences would be if the task was performed incorrectly. That is:

- What costs would be incurred as a result of the task being performed incorrectly?
- What resources would be required to remedy the situation?
- What time would it take to remedy the situation?
- What are the safety implications?
- What are the environmental implications?
- If today was my first day in the job, would I know:
  - Enough about the organisation and its different functional areas to perform the required tasks?
  - With whom I should communicate and what inputs I need, where they come from, how I access them, and whether I need someone's assistance?
  - What to do with the output of my job and to whom I should direct it?
  - If the adverse consequences of performing the task incorrectly are minimal, the task may not need to be documented.

5.2.1.1 Comprehensive Checklist of SOPs

Not all of the following SOPs will be applicable to each dam. The requirement for individual SOPs needs to be decided case-by-case. Where applicable, SOPs should be prepared to deal with the following issues.

ISSUE	REASON FOR INCLUSION
Personnel Training and Procedural Issues	
Operator Training	To ensure suitably qualified and experienced people are available to operate the dam
Documentation control and review	To ensure SOPs and other controlled documents are properly updated and only the current version of the procedures is used for dam operations
Undertaking of a Failure Impact Assessment every five years	For compliance with the requirements of the *Water Act 2000*
Setting of Normal Operation Criteria	To ensure the dam is operated and maintained in accordance with known operating limits eg gate operating limits or restricted FSL's due to stability limits
Emergency Action and Incident Reporting	
Accident and Incident Reports	To ensure incidents which may affect dam safety are documented so that they can be considered in future inspections and safety reviews
Emergency Action Plan (EAPs)	Liaison with affected population, local government and counter disaster organisations
Verification of Emergency Contact Numbers	To ensure EAPs are kept up to date and ready for use
Communication procedures and procedures covering the Loss of Communication during an Emergency Event	To ensure adequate triggering of Emergency Action Plans and to ensure dams are operated properly when communications are restricted
Attendance at dam	To address levels of attendance corresponding to operational states of the dam

Comprehensive Checklist of SOPs (cont.)

ISSUE	REASON FOR INCLUSION
Critical Operating Procedures	
Test operation of critical equipment	To reduce the risk of the equipment not operating as planned. Such a procedure should provide for: • an annual pattern of test operation of gates or other crest control devices[5] • regular testing of backup power supplies • regular testing of sump pumps • regular testing of communications
Pump operation plan for water harvesting that includes monitoring	To minimise the risk of overtopping of the dam through over-pumping
Notification of Spillway Discharge	To ensure emergency planners are aware of significant spillway discharges during flood events
Spillway Gate flood operations including: • water level monitoring procedures • discharge Control and flood release protocols including monitoring and warning of areas of impact prior to releases (for campers etc) as required in the Emergency Action Plan • coordination of releases with other dams or downstream tributaries (where appropriate) • communication security and failsafe procedures	To ensure spillway operations proceed in accordance with agreed procedures which maximise the safety of the dam and minimise disruption to flood affected communities
Bulkhead Gate Installation, Penstock drainage, Trash screen removal and installation	To ensure the safety of operations and maintenance personnel
Confined Space Access	To maximise the safety of people in and around the dam
Monitoring and Surveillance	
Water level monitoring procedures and the monitoring of inflow events	To ensure dam hydrology and spillway performance can be reviewed
Instrumentation surveillance and data recording	To ensure monitoring and surveillance is carried out and the data are rapidly analysed and reviewed
Owners routine dam safety inspection including checklists and reporting requirements	To ensure routine dam safety inspections are carried out consistently and to appropriate standards

5 This SOP must include cracking gate under full load, and raising and lowering gate under no load over full travel

ISSUE	REASON FOR INCLUSION
Monitoring and Surveillance (continued)	
Dam Safety Annual inspections (if annual inspections are required by development permit conditions)	To ensure the inspections are carried out consistently and to appropriate standards
Dam Safety 5 yearly comprehensive inspection (if required by development permit conditions)	To ensure the inspections are carried out consistently and to appropriate standards
Requirement for inspection during and after flood events and after seismic events	To ensure the emergency action plan and any remedial works are triggered during and after such events
Inspection, testing and maintenance of mechanical and electrical equipment	To ensure mechanical equipment can be operated as designed whenever necessary
Log Book	
Maintenance of Dam Log Book	To ensure operations and maintenance activity and associated decisions are recorded
Log book should include major events such as: • equipment testing • major planned and unplanned maintenance and special one off jobs at the dam • testing of gate functions • painting programs • flood discharges and reservoir levels • incident details • reports dispatched and received • notification of receipt of changes to documentation (eg SOPs)	To record major and exceptional events and conformance with procedure

5.2.2 SOPs Checklist

The following comments are suggested to assist in the preparation of SOPs:

- Preliminary pages of the combined SOPs should include:
  - cover sheet
  - title page
  - table of contents
  - revision sheet
  - any necessary certification and/or verification required by the dam owner
  - an aerial photo of the dam if possible.
- In terms of formatting, it is recommended to:
  - bind SOPs in loose-leaf folder so that it is easy to make revisions, additions and updates
  - start each procedure on a new page
  - use a standardised format for each procedure
  - the title of each procedure should be short and adequately identify the task
  - use lists rather than narration to outline instructions and information whenever possible.
- All areas of responsibility in the administration, operation and maintenance of the dam should be clearly indicated in the SOPs. Some of the operational aspects of dam ownership and operation that should be addressed include:
  - operation of equipment at the dam
  - reservoir inflow and flood forecasting
  - authorising spillway flood releases
  - authorising irrigation releases
  - recording reservoir data
  - routine inspection
  - maintenance
  - modification
  - correct method of opening and closing guard gates
  - dam safety and surveillance.
- The operating personnel responsibilities should be specifically identified and should include regularly scheduled duties personnel are required to perform.
- Administrative and operational relationships between the various operating and end user organisations should be detailed. (Both formal and informal agreements should be referenced.)
- Organisational arrangements in the form of flow charts can be beneficial. For example, agreements on allocation of responsibility for operation.
- Write procedures clearly and concisely. Avoid using vague words (for instance use a specific word such as "annually" rather than the word "periodically").
- Each procedure should identify the step-by-step actions or groups of actions in sufficient detail to describe the task in a logical manner.
- Where appropriate, include drawings, sketches, graphs, manufacturer's instructions, photographs etc in appendix or text to increase understanding.
- Where appropriate, if a SOP requires a form or forms to be filled out to confirm that a task described in the SOP was undertaken copies of the form should be appended to the SOP.
- Where appropriate, the use of drawings, marked photographs, colour coding and numbering of valves and switches are recommended to supplement step-by-step operation or maintenance instructions. These aids simplify instructions and reduce the chance of error in their use.

5.2.3 Level of Attendance

The owner should ensure that the level of operator attendance for the dam is appropriate for the failure impact rating of the dam as well as the:

- consequences of the dam failure
- proximity of the population at risk and the available warning time
- remoteness of the dam and ease of access during flood events
- reliability of remote sensing and transmission of warning trigger data to offsite control centres
- availability of backup operations personnel
- other activities conducted at or near the dam by the dam operator
- need to trigger Emergency Action Plans
- complexity of gate operations and associated need for skilled operators
- preparedness of operations staff
- inspection post seismic or flood events compared with monitoring as flood event evolves.

For example, the level of attendance for a particular dam with a Category 1 failure impact rating which has simple operating requirements, a distant population at risk and a long warning time, may involve regular visits and inspections (eg daily visits and inspections). In contrast, a dam with a Category 2 failure impact rating with complex operating requirements and a high population at risk in close proximity, may require qualified dam operators in residence and/or an appropriate electronic surveillance, control and communication system. The reliability of electronic systems should be considered in determining the level of attendance during flood events.

Further, a dam owner may wish to assign the operation of a dam to a nominated operator (the dam owner still retains responsibility for dam safety). If this occurs, the dam owner should ensure the nominated operator:

- is aware of the potential damage which could result from the different modes of failure relevant to the dam
- is aware of the Designers Operating Criteria and what constitutes an abnormality
- operates the dam in accordance with SOPs
- participates in dam safety inspections and the surveillance program
- is empowered to initiate Emergency Action Plans should the need arise
- is empowered to communicate directly with the relevant parties (eg advise chief executive of NR&M) should there be a need to operate the dam outside a SOP.

5.3 Detailed Operating and Maintenance Manuals

While a SOP outlines the protocols for operation of a system in the dam (eg water releases by gate operation), Detailed Operations and Maintenance Manuals (DOMMs) address how to operate, maintain and overhaul individual pieces of equipment for a dam and its associated structures (eg the operation, maintenance and replacement of valves and motors for the gates). The dam owner should operate and maintain the dam in accordance with the DOMMs.

The DOMMs are important as equipment, which is operated or maintained in an incorrect or inappropriate manner, can affect the safety of a dam. Significant work should not commence on equipment for a dam and its associated structures without proper authorisation from the dam owner.

The information in the DOMMs should be complete, accurate and up to date and cover all facilities and equipment. Further, for those issues which are critical to the safety of the dam, the dam owner should ensure the DOMMs are reviewed annually so that the manuals remain accurate and up to date.

The manuals should contain the following:

- Work Instructions, which detail the way in which equipment should be operated and outline the steps involved in performing a task. For example, a work instruction may be developed for the use of the gantry crane for placement of bulkheads gates.
- Maintenance Schedules, which detail the asset, description of task, frequency of maintenance and special requirements for servicing and maintaining the equipment. For example, a maintenance schedule should be developed for maintaining and servicing all mechanical and electrical equipment.
- Equipment data sheets or Manufacturer's Manuals, which comprise technical information needed for maintenance, repair and overhaul of equipment. For example, an equipment data sheet or manufacturer's manual should exist for the operation, maintenance, repair and overhaul for the emergency generating set.

Dam owners should ensure that DOMMs developed for their dam reflect the operating complexity, location of the dam and distribution of responsibilities between maintenance and operational personnel. The DOMMs should be located on site at the dam at least for day-to-day use. For procurement and administrative reasons, it may be advisable to hold a second copy in the dam owner's office. This is particularly important for structures with variable flow control.

The DOMMs or at least their drafts should be available prior to the initial filling of the reservoir.

5.4 Recording and Work Assignment system

The Recording and Work Assignment system issues detailed work orders for operational staff (and others such as consultants) and records the outcomes of the order. Work orders originate from requirements of the SOPs and DOMMs. These work orders set out who is responsible for work, supervising responsibilities, recording details of the work and the date of the work. Dam owners should have a Recording and Work Assignment system which is capable of issuing and tracking work orders.

The Recording and Work Assignment system can consist of:

- checklists
- logs
- card files
- computerised systems.

This system plays an important role in verifying work undertaken on the dam for dam safety purposes.

6 Surveillance

6.1 Introduction

Surveillance is the continual examination of the physical condition and operation of a dam. Surveillance programs should be capable of detecting problems or unsafe conditions at an early stage so that corrective measures can be taken and dam safety is not compromised. To obtain a historical context for defects, surveillance should commence as early in the life of the dam as possible to detect the development of any problem or unsafe trends and to provide full background information on a dam's performance.

A dam safety management program begins with the initial investigation of the dam foundation and continues through its design, construction and operation. While many problems may occur and need to be overcome during these phases, there is always a risk that not all problems have manifested themselves or been detected by the time the dam has reached its operational phase.

Any unusual behaviour, regardless of how seemingly insignificant, should be identified and recorded because this may be the forewarning of a newly developed unsafe condition.

The causes and processes of dam failure are varied and the knowledge gained from previous dam failures has contributed to the advancement of specialised knowledge essential to the prevention of further failures. Case histories of dam incidents reveal many remarkable similarities in antecedent conditions and processes of deterioration.

Each dam should have its own surveillance program. The scope of a surveillance program should be appropriate to the size of the dam and storage, the population at risk and other consequences of dam failure, the level of risk at the dam, and the value of the dam to the owner.

A surveillance program should include:

- monitoring of instrumentation
- collection of information or data relating to dam performance (eg investigation, design and construction reports)
- evaluation and interpretation of the data
- a range of inspections, from routine inspections by operational staff through to comprehensive inspections by engineers.

Each of these is considered in more detail in the following sections.

Experienced dams engineers should be consulted on the nature and extent of suitable surveillance programs. Generally, larger more complex structures with novel design features require more detailed and comprehensive surveillance programs. These should be instigated during the design and construction phases and in response to emergent problems.

6.2 Monitoring

Monitoring is the collection, presentation and evaluation of information from measuring devices installed at or near dams. Monitoring is needed:

- to detect deterioration in performance of the dam
- to detect trends or behaviour to establish compliance with design expectations (If the trends

indicate non-compliance with design expectations, remedial action should be initiated.)
- to rectify dam design issues which could not be resolved to high reliability during the design and construction stages (Such issues can only be addressed with a monitoring strategy, which can substantiate design expectations by establishing a correlation with actual behaviour. Some behaviour responds slowly over many years while some may not become evident for many years.)

The designer, review engineer, or inspection engineer should identify the issues that need to be monitored and incorporate appropriate instrumentation into the dam. For instance, for a farm dam, it may be concluded that there is no need for any instrumentation. Forms of monitoring include:

- deformation surveys
- water level measurements (including rainfall)
- seepage and pore pressure measurements
- measurements to confirm design parameters
- foundation pressure management
- stresses in embankments or structural components
- spillway performance and condition
- monitoring of deficiencies (eg cracking or erosion)
- seismic monitoring
- level of surveillance data.

The preferred frequency of monitoring varies over time. Factors influencing the frequency of monitoring include:

- the consequences of a dam failure
- the nature of the behaviour being monitored
- the stage of maturity of the dam (eg monitoring should be more intense during the construction and initial filling stages than during the operational phase)
- the existence of any problems or events (eg special events, such as record floods and earthquakes, will require more intense monitoring).

Dam owners should ensure that dam monitoring programs are reliably executed and that all instrumentation is maintained in a reliable condition and provides accurate readings throughout the life of the dam. Instrumentation available varies according to complexity, robustness and cost. Regardless of the instruments used, the dam owner must be able to ensure that the appropriate standard of monitoring is achieved.

The designer of the dam should determine the monitoring program, instrumentation used and frequency of observations initially in the design and construction phase. Dam owners should have a dams engineer review the appropriateness of the monitoring program, the instrumentation used and the frequency of observation as part of each comprehensive dam safety inspection. Instrumentation may need to be retrofitted if potential problems are identified.

There may be potential for remote monitoring and automation of data collection. However, malfunctions of remote monitoring and automatic data gathering during times of extreme weather conditions suggest that careful consideration be given to the reliability of such systems, especially when some form of operational control relies upon the monitoring. Owners should ensure that backup facilities are available for checking remote monitoring and accessing operational data for the dam during critical periods.

As the design and installation of instrumentation systems is a specialised area of dams engineering, dam owners should engage engineers experienced in this field.

The inclusion of accelerometers in dams in cooperation with wider seismic networks (state or national)

should be considered. This is important in seismically active areas or for large dams where reservoir induced seismicity could occur. Interpretation of data and maintenance of systems should be undertaken by a seismologist.

6.3 Data collection and management

Dam owners are responsible for the collection, storage and presentation of all data associated with the operation and maintenance of a dam. There are two types of data:

- Static data does not change with time. Such data will normally be stored in the data books, dam safety reviews and reports. Static data usually encompasses all design and construction investigations, including the Designers Operating Criteria. Much of this information is found in the Design Report and As-Constructed documentation.

As much of the static data will never be changed, it may be reduced and stored on microfilm or some electronic storage medium. Sufficient, easily accessible information should be kept on hand in Data Books to provide information for any situations which could arise.

- Dynamic data changes with time. It includes data derived from dam safety surveillance, monitoring, operations and maintenance activities. This data is accumulated in the Dam Safety Inspection and Surveillance Reports. Much of the dynamic data is suitable for computer storage and presentation, particularly that arising from monitoring.

For data collection and management purposes, dam owners should be aware of:

- the strengths and limitations of computer storage and retrieval systems (eg ease of access for retrieval of information)
- issues associated with compatibility of computer systems.

Dam owners should ensure that the system used to collect and process the data has facilities to detect the occurrence of "obviously different" data, which can be caused by:

- data recording and transfer errors
- instrumentation malfunction
- abnormal behaviour of the dam.

These situations should be investigated immediately. If the change is attributed to abnormal behaviour, the owner should initiate further investigations to explain the abnormality and ensure that it is not indicative of a worsening dam safety situation. These abnormalities can be a trigger for remedial action.

6.4 Surveillance evaluation

Not all dam deficiencies can be detected by visual inspections. There are many cases where an analysis of surveillance data has detected problems not evident by other means. Surveillance evaluation is an assessment of the safety of a dam in terms of its condition and operation based on data obtained from dam safety inspections and monitoring.

Data is accumulated during the course of surveillance, monitoring and operation of a dam. For ease of understanding, it may be beneficial to reduce this data into graphical form. Dam owners should ensure this data is evaluated on a regular basis to monitor the continued safety of each dam. Data evaluation should be assigned to an experienced dams engineer who should make recommendations based upon their interpretations.

Some examples of how areas of dam performance are considered in a surveillance evaluation include:

- assessment of the available pressure, movement and seepage monitoring data by analysis of the impact (if any) of all monitoring results
- assessment of the seepage from the storage (A plan should be provided showing position, quantity, and quality of seepage.)
- the recent movement survey for the dam
- the foundation and embankment pressures being experienced by the dam. A plan showing the position and purpose of the individual piezometers should be provided.

Surveillance evaluation is conducted as part of a periodic dam safety inspection (at five yearly intervals), although evaluation may be undertaken at more frequent intervals or at times of concern.

Following evaluation, a Surveillance Report should be prepared. Experienced dam engineers familiar with the entire history of the dam should prepare this report. The Surveillance Report should:

- review all dam safety inspections and surveillance data for a dam
- identify any anomalous trends
- make recommendations on any actions required to ensure the continued safety of the dam
- summarise and extend previous reports to provide a clear picture of long-term trends.

Anomalies and concerning trends identified in the Surveillance Report should be considered as deficiencies. It is the responsibility of the dam owner to ensure that appropriate remedial actions are taken and documented. Further guidance on surveillance evaluation can be found in Appendix 3.

6.5 Dam safety inspections

One of the most important activities in a dam surveillance program is the frequent and regular dam safety inspection for abnormalities in conditions and deterioration of the dam.

Dam safety inspections are conducted to determine the status of the dam and its features relative to its structural and operational safety. Different types of dam safety inspections should be undertaken for different purposes:

6.5.1 Routine inspections

Purpose:	To identify physical deficiencies of the dam.
Reporting:	There is no standard report for these inspections as they can vary from a short weekly check for a small farm dam to a twice daily dam check using a checklist.
Undertaken by:	The dam owner or field and operating personnel as part of their normal duties at the dam.
Discussion:	Routine Inspections are best carried out by someone involved in the day to day running of the dam. Much of the inspection and observation should be incorporated in the daily work routine of such officers. The Standing Operating Procedures (SOP) should outline the requirements regarding: • the timing and frequency of the inspections • who should be involved (In some cases electrical expertise may be needed to inspect some elements of dams.) • the reporting requirements.

6.5.2 Periodic inspections

Purpose: Generally carried out by a dams engineer with the purpose of identifying physical deficiencies of the dam by visual examination and review of surveillance data against prevailing knowledge.

Reporting: The report should fully document the status of the dam and all defects or unsafe conditions and outline a strategy for taking remedial action (including preliminary costing and, if several defects or conditions are found, prioritisation of actions).

Undertaken by: An experienced dams engineer who is a Registered Professional Engineer (RPEQ).

Discussion: The inspection should assess all physical aspects of the dam. A periodic inspection requires preparation of checklists, preparation of mechanical equipment, and preparation of access (confined and difficult areas). These inspections are generally carried out on a five yearly basis. However many dam owners may opt to undertake a less extensive periodic inspection more regularly (eg annually). This inspection may exclude aspects of five yearly inspections such as:

- a test operation of all equipment
- evaluation of all surveillance data
- major function checks and maintenance inspections. For example:
  - flip bucket dewatering
  - conduit dewatering
  - diver inspection of intake works
  - conduit video inspection.

The timing of the inspection depends on the regional weather pattern. For example, if a distinct wet season exists inspections are best carried out immediately after the wet season, to allow remedial work to be planned and undertaken prior to the next wet season. Guidance on these inspections follows in Appendix 4.

6.5.3 Special inspections

Purpose: The examination of a particular physical feature or operational aspect of a dam for some special reason. For example, a special inspection may be carried out on a particular feature of a dam that has been identified as having a possible deficiency or has been subject to abnormal loading conditions.

Reporting: The report should fully document the status of the particular physical feature or operational aspect of a dam subject of the investigation as well as any other defects or unsafe conditions and outline a strategy for taking remedial action (including preliminary costing and, if several defects or conditions are found, prioritisation of actions).

Undertaken by: A specialist dams engineer.

Discussion: These inspections are often carried out with a degree of urgency. It requires some insight into the nature of the feature or defect being investigated to determine what specialist needs to be engaged to carry out the inspection. The inspection will address only issues that relate to the subject feature and is in addition to the regular and periodic inspections. Guidance on these inspections follows in Appendix 4.

6.5.4 Comprehensive inspections

Purpose: A periodic inspection of the dam and a review of the owner's whole dam safety management program.

Reporting: The report should assess all aspects of the dam safety management program and fully document:

- deficiencies identified in the dam safety management program and its documentation
- a strategy for overcoming the deficiencies (including prioritisation of actions if several deficiencies are identified).

Guidance on these inspections follows in Appendix 4.

Undertaken by: An experienced dams engineer who is a RPEQ.

Discussion: This inspection should incorporate:

- a periodic inspection
- an assessment of the appropriateness and adequacy, the effectiveness and application (including the owner's response to inspection report and Safety Review recommendations) of the dam safety management program and documentation for the dam including:
  - SOPs
  - DOMMs
  - Emergency Action Plan
  - Data Book
  - Design Report/Safety Review
  - Surveillance and inspection program and records.

(This assessment should take into account applicable development permit conditions for the dam and the requirements outlined in this guideline.)

6.5.5 Regulatory audits

Purpose: Independently, NR&M in its role as Regulator may audit dam safety management programs for referable dams in Queensland. These audits will generally examine compliance with development permit conditions dealing with dam safety and the outcomes of inspections and Safety Reviews. Such audits assist dam owners to compare their practices with industry standards.

Undertaken by: NR&M

Reporting: The report may indicate:

- deficiencies in the dam safety management program and its documentation
- non-compliance with development permit conditions
- proposed actions by NR&M and the dam owner
- comments on the efficiency and the effectiveness of the dam safety management program.

Discussion: Generally the audit will be carried out on dams at random. Dams with a questionable management performance record are more likely to be audited. The outcome of these audits will assist NR&M to assess the effectiveness of their regulation program throughout the state.

7 Safety Reviews

7.1 Introduction

A safety review is a procedure for systematically assessing the safety of a dam after its original construction. It is a fresh engineering assessment of the integrity of all elements of a dam. It usually incorporates a:

- current failure impact assessment
- detailed review of structural, hydraulic, hydrologic and geotechnical design aspects
- review of historical operational performance
- review of surveillance reports
- comprehensive inspection of the dam
- comparison of the standards used for building and upgrading the dam against current design standards.

7.2 Steps involved in a Safety Review

The steps involved in a safety review include:

- Collect background information on the dam. This includes all relevant historical investigation, design, construction, remedial, operation and maintenance, monitoring and inspection data.
- Compare the performance of the dam with the standard set by the original design engineers (if known) and the relevant standards and guidelines existing at the time of the review. The review must include a prediction or assessment of the theoretical performance of the dam against current standards and guidelines.
- Where design aspects are based on assumptions or are incomplete, the Safety Review should include basic investigations and detailed analysis to substantiate the design.
- In the case of incomplete documentation, further investigations may be required, particularly in the case of an initial safety review. Where insufficient plans or data exist of critical elements, additional investigation activities should be undertaken to resolve uncertainties. Typical investigation activities include:
  - survey to establish lines and dimensions
  - testing of materials in the dam and its foundation
  - geological drilling and mapping
  - calculation of revised flood estimates
  - updating of earthquake forces.

Particular attention should be given to changes in land use that may have occurred since construction of the dam which may affect design and operation criteria. This includes such activities as mining, urbanisation or clearing of the catchment area both upstream and downstream of the dam.

The design assumptions and standards used should be reviewed and compared with current best practice, eg

- the foundation integrity (bearing, seepage) applied should be reviewed and compared with current best practice
- the spillway adequacy should be reviewed and compared with current accepted engineering standards, ie ANCOLD–Guidelines on Selection of Acceptable Flood Capacity for Dams
- the embankment and outlet structure should be reviewed and checked as to whether it can withstand appropriate loadings (including seismic) in accordance with current engineering practice.

Conclusions should be developed regarding the adequacy of the main elements of the dam (ie foundations, main wall, spillway, outlet works, associated equipment and monitoring system).

Comments should be made regarding adequacy of the dam safety surveillance and inspection program and operation and maintenance procedures. Such comments and conclusions should reflect prevailing knowledge in hydrology, hydraulics, soil mechanics, geology, structural analysis and design criteria relating to dams.

Further guidance in the issue to be addressed when undertaking a Safety Review can be obtained from Appendix 3 - Checklist of Dam Technology Issues.

The level of sophistication of Safety Reviews varies depending on the complexity of the dam. For example, a Safety Review for a large gated structure requires a greater range and depth of studies than for a small grassed bywash earth dam. In addition, Safety Reviews are not necessarily completed when the Safety Review Report is finalised. Subsequent investigations recommended in the Report are often required and may take years to finalise.

7.3 Frequency of Safety Review

The frequency of dam safety reviews is generally based on the age of the dam and the appropriateness of the technology used on that dam. Safety reviews are generally conducted on a maximum twenty-year cycle but may also be initiated in response to issues such as:

- an absence of design and construction documentation
- a regulatory requirement
- detection of abnormal behaviour
- changes in acceptable design and construction standards
- proposals to raise or modify a dam
- changes in Standing Operating Procedures.

7.4 Safety Review personnel

the Safety Review of a dam can be quite complex and personnel engaged in safety reviews should be experienced in dam technology. Where necessary, the services of suitably experienced geologists, hydrologists and other specialists should be utilised. Consideration should also be given to independent review by engineers other than those who carried out the original design of the dam.

7.5 Safety Review Reports

A Safety Review Report should be produced to document the safety review and should include:

- a statement on the safety of the dam indicating whether or not the dam is in a satisfactory condition and capable of meeting current design criteria
- report on comprehensive inspection
- parameters adapted and assumptions made (and their bases) for review analyses)
- methods of review analyses and results (numerical and physical)
- identification of any deficiencies in the dam including criticality ratings for these deficiencies[6]
- recommendations for remedial work, emergency action and/or further studies which should be undertaken and timings for these.

6 A deficiency may be insufficient knowledge about a particular aspect of a dam.

Whilst dam owners may engage consultant engineers to carry out the Safety Review and prepare the report, the recommendations contained in a Safety Review Report will be considered as originating from the dam owner. The dam owner will be responsible for implementing the recommendations. Comprehensive inspections and ultimately audits undertaken by the Regulator, will evaluate the dam owners response to Safety Review Reports.

When preparing a Safety Review Report the reviewer should consult the checklist of dam technology issues included as Appendix 3—Checklist of Dam Technology Issues.

8 Deficiencies, Incidents, Failures and Remedial Action

8.1 Introduction

There are a number of situations that may require remedial action at a dam. These situations can vary from a minor deficiency in the dam, to a major incident or even dam failure.

A deficiency threatens the safety of a dam and may be detected by surveillance inspections and evaluations or dam safety reviews. Deficiencies include:

- inappropriate or deficient design or construction
- changes to design criteria
- changes in the failure impact rating of the dam (for example an increase from a category 1 failure rating to a category 2 failure impact rating)
- time based deterioration or breakdown of material;
- maintenance related problems
- deficiencies in the dam safety management program
- inappropriate operating techniques
- inadequate surveillance procedures
- damage to dam (eg landslides, erosion, earthquake etc).

An incident is an event, which could deteriorate to a very serious situation or endanger the dam. Examples of incidents include:

- rapid change in seepage
- overtopping of earth embankment
- excessive beaching
- excessive embankment erosion
- spillway or bywash erosion or blockage
- excessive cracking or displacement in concrete dams and spillways
- sliding, rotation or settlement of the dam
- malfunction of gates or crest bags.

The failure of a referable dam means the physical collapse of all or part of the dam or the uncontrolled release of any of its contents. Causes of failure include:

- overtopping of embankment dams
- collapse or erosion of spillways
- internal erosion or piping through earth embankments or abutments
- failure of release conduits
- overturning of concrete dams
- deterioration of maintenance deficiencies.

8.2 The need for remedial action

Remedial action is required in response to a deficiency, incident or dam failure. The type of remedial action required and its urgency is determined by the nature of the event.

Remedial action may include:

- preventative measures to stop situations worsening;
- short term actions such as activation of Emergency Action Plans (including evacuations), installation and operation of warning systems, modification of operating procedures including lowering of reservoir levels by controlled release and increased surveillance;
- long term actions such as structural changes to a dam;
- changes to operating procedures;
- decommissioning of a dam.

In life threatening situations, remedial actions may involve short-term actions including the removal of persons at risk, modification to operations, controlled release of storage, increased surveillance and provision of alarm systems.

8.3 Remedial action review

There may be a number of remedial actions which can be undertaken in response to an incident, deficiency or failure. A Remedial Action Review should be undertaken which methodically evaluates the various options.

The Remedial Action Review should include:

- determination of the risk of failure of the dam
- preparation of a failure impact assessment to determine the current population at risk and a consequence assessment to determine other consequences such as economic and environmental damage
- development of possible solutions
- quantitative risk analysis
- estimation of the benefits and implementation costs of each solution
- justification for the adoption of the preferred remedial action.

8.4 Communication of incidents and failures

All dam incidents and failures, either actual or suspected, should be documented. If the dam owner is not already aware of the incidents and failures, such information should be conveyed by the dam operator (or consultants) to the dam owner for consideration and action[7]. Dam owners should ensure that permanent records of such events are kept in the dam safety inspection and evaluation reports.

7 Information on dam deficiencies is provided to the dam owner as a part of periodic and comprehensive inspections.

9 Emergency Action Planning

9.1 Introduction

An Emergency Action Plan (EAP) is a formal plan that:

- identifies emergency conditions which could endanger the integrity of the dam and which require immediate action;
- prescribes procedures which should be followed by the dam owner and operating personnel in the event of an emergency;
- provides timely warning to appropriate emergency management agencies for their implementation of protection measures for downstream communities.

The standards used for design, construction, operation, maintenance and inspection of dams are intended to minimise the risk of dam failure. However, as unusual circumstances could result in dam failure, dam owners need to identify conditions which could lead to failure situations and which may require dam safety emergency planning.

Emergency planning takes place at two levels:

- to prescribe activities at the dam - known as the Emergency Action Plan which is prepared and operated by the dam owner, and
- to prescribe activities below or beyond the dam - known as the Counter Disaster Plan, which is prepared and operated by the appropriate local Disaster District Co-ordination Committee (DDCC) with significant input from the dam owner.

An EAP should indicate who is responsible for undertaking particular actions under emergency circumstances and must be tailored to the conditions at each dam.

9.2 Dam owner's role

A dam owner should:

- develop and maintain an EAP
- in all emergencies, respond in accordance with the EAP
- determine the area of potential inundation or other impact from dam failure
- establish and maintain a communication system for the timely notification of impending and actual emergencies
- provide the Disaster District Co-ordination Committee (DDCC) with details of emergency response actions at the dam (eg, flood releases) and estimates of their downstream impacts
- develop a test schedule to ensure the EAP is functional and staff are familiar with the EAP.

9.3 Process for developing an EAP

When developing an EAP, the following steps should be taken by, or on behalf of, the dam owner:

- determine and identify those conditions that could forewarn of an emergency and specify the actions to be taken and by whom under what circumstances
- in consultation with the District Disaster Coordinator (DDC) for the impacted area (or the Disaster District Manager from the Department of Emergency Services), identify all jurisdictions, agencies and individuals who should be involved in the EAP (for example, local governments, the Queensland Police Service and downstream residents)
- identify response actions to be taken in response to potential emergencies

- identify any necessary resources, special tools, equipment, keys and indicate where they can be located if required in an emergency
- list and prioritise all persons and entities (including contact details) involved in the notification process and the roles and responsibilities assigned to them (eg a flow chart may be used)
- identify primary and secondary communication systems, both internal (between persons at the dam) and external (between dam personnel and outside entities)
- develop a draft of the EAP
- hold meetings with all parties (including emergency management agencies) included in the notification list, to review the draft EAP
- make any revisions, obtain the necessary plan approval and disseminate the EAP to those who have responsibilities under the EAP
- test and revise the EAP at regular intervals.

9.4 Issues To Be Considered In Emergency Action Plans

An Emergency Action Plan (EAP) needs to be easily identified. Consequently, it is recommended that the EAP is contained in a hard covered A4 sized folder, colour coded red.

The issues to be included in an EAP should be as follows.

1. Distribution control sheet (which is page 1)

It is important that the current EAP is issued to a number of parties including:

- Dam Operator
- Specific dam personnel with roles in the EAP
- Chief executive NR&M
- Local counter disaster groups (eg Disaster District Co-ordination Committee (DDCC) and local Government Counter Disaster Committee (LGCDC))
- Local governments which may be affected by the emergency.

Details of these parties should be listed on the distribution control sheet.

2. Title Page/Cover Sheet

3. Table of Contents

4. Notification listing or flowchart

This listing or flow chart should clearly summarise the following:

- Who is responsible for notifying each dam owner representative(s) and/or emergency management official(s) and others (eg residents located immediately downstream of a dam)?
- What is the prioritised order in which individuals are to be notified?
- Who is to be notified?

The listing or flowchart should include current individual names, position titles, office and home telephone numbers, alternative contacts and means of communication. Where applicable, radio frequencies and call signs should be detailed.

The number of persons to be notified by each responsible individual on the flowchart should be governed by what other responsibilities the person has been assigned. It is usually recommended that any one individual not be responsible for contacting more than three or four other parties.

The following parties should be considered for inclusion in the notification listing or flowchart:

- dam owner
- local emergency management officials (DDCC and LGCDC) and other organisations
- appropriate state emergency management agencies
- residents and property owners located immediately downstream of the dam within the boundary of potential inundation where available warning time is very limited
- local governments which may be affected
- operators of other dams or water-retention facilities which may be affected

- managers and operators of recreation facilities which may be affected
- Bureau of Meteorology.

The decisions as to who needs to be contacted will depend on the scale and timing of the potential impacts.

5. Roles and Responsibilities

The responsibilities of the following parties should be specified:

- dam owner
- dam operator
- other dam personnel with a role to play in the EAP (including standby officers where appropriate).

Specific roles, which should be addressed in terms of responsibilities, include:

- notification of local counter disaster agencies (such as DDCC and LGCDC) and dissemination of information to the media and public
- notification of evacuation (eg in the case of a resident located just downstream of the dam the dam owner may need to notify that person directly)
- on-site monitoring of the situation at the dam and keeping parties informed of developing conditions at the dam from time to time
- other actions (eg opening of gates etc where appropriate)
- follow-up evaluation after the emergency (including an Emergency Event Report).

6. Area map

This map should show access routes to the storage during fair and adverse weather conditions, identifying travel times and distances.

7. Drawing of the Storage Catchment Area

8. Emergency Events and action list

Typical emergency or potential problem identification includes but is not limited to:

Problem	General characteristics	When and what to check
Overtopping imminent	Storage full and water level rising - check water levels	During periods of excessive rainfall
Wave erosion	Beaching or notching of the upstream face of embankments by waves generated over long periods of strong wind	During or after periods of strong wind - inspect upstream face of embankment
Toe erosion	Erosion of embankment toe by spillway discharge or diversion flows	During and after large rainfalls - inspect embankment toe

Problem	General characteristics	When and what to check
Gullying	No armouring or vegetation cover on embankment batters or poor drainage	During and after large rainfalls inspect embankment batters for damage to armouring or vegetation cover
Loss of storage contents	Excessive loss from the storage and/or occasionally increased seepage or increased groundwater levels near the storage	During routine monitoring - look for environmental changes such as vegetation damage, salt scalds, etc
Seepage erosion or piping	Progressive internal erosion of the embankment or foundation to form an open conduit or pipe	During routine inspection or after unaccountable increases in seepage flows, look for an emission point
New springs, seeps or boggy areas	Evidence of internal changes in seepage control (could be initial signs of piping failure)	During routine inspection, look for "evergreen" spots, boggy ground or pools of water
Rapid increases or cloudy appearance of seepage	Seepage flow through the storage embankment is cloudy and increasing (piping failure has started)	After detection of cloudy water at seepage monitoring points - look for the source of cloudy water
Increase in gallery seepage	Increase in the normal rate of gallery seepage	After detection - check for differential movement or cracking in concrete components
Foundation failure	Sliding, rotation or settlement of part or entire dam	During routine inspection or immediately after earthquakes - inspect for evidence of foundation movement or displacement immediately adjacent to dam
Slide in downstream slope	Slide in the downstream face	During routine inspection - look for cracks or scarps near the crest and bulges at the toe
Flow slide	Collapse and flow of soil around the storage periphery	During routine inspection and especially with sedimentary/ colluvial soils - look for material displacement around the storage rim