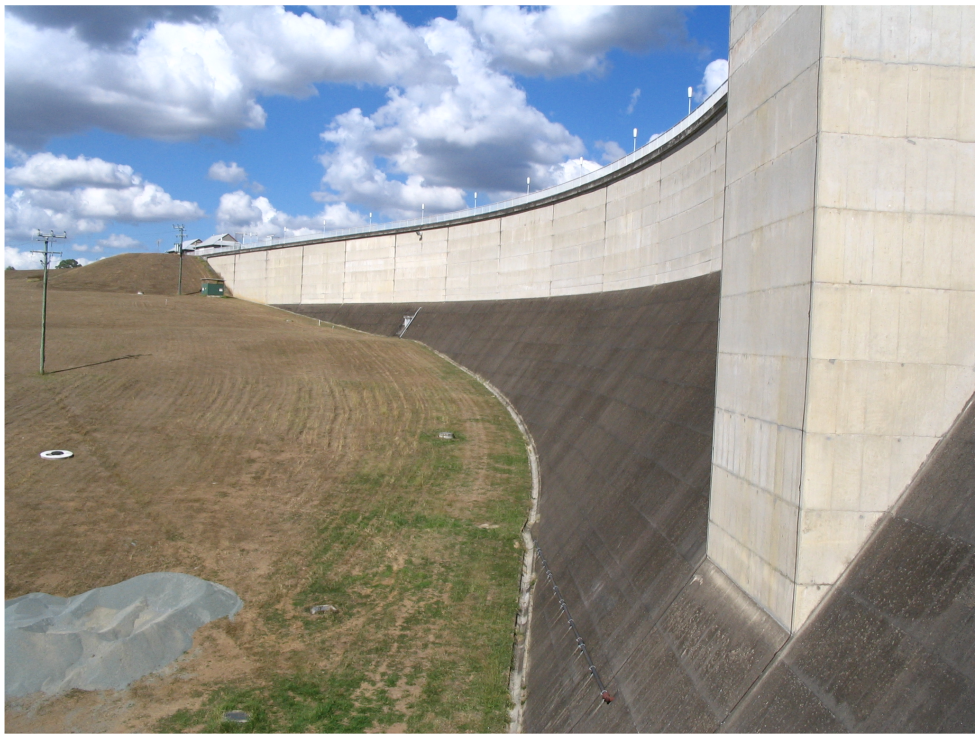
Queensland Government
Natural Resources and Water

SEQWATER WATER SERVICES DAM SAFETY AUDIT



June 2007

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EXECUTIVE SUMMARY

SEQWater own and operate Wivenhoe, North Pine and Somerset dams.

The aim of this audit is to review the conformance of SEQWater against the Development Permit Dam Safety Conditions issued by DNRW. The Queensland Dam Safety Management Guidelines (2002) as well as the ANCOLD Dam Safety Management Guidelines (2003) are also considered where appropriate.

Organisations such as SEQWater have numerous regulatory requirements. To address this they have prepared a Calendar of Dam Actions highlighting requirements, timing and responsibilities. All the regular reporting requirements for the Safety Conditions are incorporated in this Calendar. SEQWater have also produced a Dam Safety Management Program which aims to demonstrate their compliance with obligations. It outlines their dam safety policy, objectives as well as the elements of their dam safety management program. Both documents proved to be useful references for this audit and presented SEQWater as an organisation having a professional approach to dam safety management.

From brief site visits and discussions with the Operations Engineer, a very effective maintenance program appears to be in place. Combined with this, staff are well trained and supported with documentation and resources. Significant backup is available from SEQWater rangers and the maintenance and dam safety contractor - SunWater.

Design reports do not exist for North Pine and Somerset dams but computation files are available. As no backup copies exist of the computation files, a suggestion for improvement is that any relevant information be summarised in a design report so that the key information will always be available. The Data Books for the three dams do not meet the requirements of the Queensland Dam Safety Management Guidelines. Summarising the computational files and referencing this information in the Data Books would be likely first steps in any future update.

A rewrite of the O&M manuals for the three storages is underway (expected to be completed by December 2008) which is a major resource commitment. Other potential documentation improvements such as developing design summaries from computational files and upgrading Data Books are likely to be considered as low priority tasks at this time.

Discussions with the Operations Engineer indicated that the ‘As-Constructed’ drawings for all three dams are catalogued and scanned. Drawings for the recent upgrade works at Wivenhoe are scanned separately. Superseded drawings need to be identified and a completed set of current drawings for Wivenhoe combined into one set of records.

Risk assessments in 2000 identified that the spillway capacity of Wivenhoe Dam and the North Pine Saddle Dams posed unacceptable risks based on industry guidelines. Expert panels were used to review design options and upgrade works have since been completed. A risk based approach was used to justify a staged upgrade of the

Wivenhoe spillway. Further detailed investigations are underway for North Pine and Somerset to address areas of uncertainty such as flood adequacy, gate reliability and saddle dam safety factors. This information will be used to review the portfolio risk assessment in order to prioritise and program future major works. Based on the above actions, SEQWater are following industry best practice with their approach to risk reduction.

The Standing Operating Procedures (SOPs) conform with the Queensland Dam Safety Management Guidelines. A number of minor suggestions for improvement have been noted for consideration in future updates.

The inspection (Annual and Comprehensive) and Safety Review reports were of a high standard and generally undertaken as per Safety Condition requirements. Importantly, recommendations from the reports were reviewed with follow up occurring where appropriate. In the case of Safety Review, recommendations and actions are reported upon in SEQWater's Dam Safety Management Program.

An update of the Emergency Action Plans (EAPs) is almost completed and a revision of the Flood manuals was undertaken earlier this year. Emergency documentation meets the requirements of Guidelines as well as the Water Act. Regular training is undertaken in conjunction with these documents, mainly from a flood perspective.

Under Clause 497 of the Water Act 2000, manuals for 'Operational Procedures for Flood Releases from Wivenhoe/Somerset/North Pine' dams are required to be prepared and forwarded to DNRW. The Procedures were last updated in April 2007. They are concisely written, backed up with modelling tools & training with reliable links to field personnel and catchment monitoring. A flood engineer is on 24 hour call. The flood centre is in the Hall Chadwick Centre (Floor 9, 120 Edward Street) with a backup at Mineral House. Note that the facilities at these centres were not reviewed as part of the SEQWater dam safety audit as they will be incorporated in the SunWater audit. The Flood Manuals are linked to EAPs and initiated whenever a spillway discharge event is deemed likely. The EAPs outlines responsibilities for when flood triggers are reached. Overall, emergency documentation and preparedness were considered to be of a very high standard.

The core function of SEQWater is dams management. The benefit of this focus was highlighted throughout the audit in areas such as staff training, the availability of comprehensive documentation and a structured approach to minimising unacceptable dams risk. No major Safety Condition non conformances were identified amongst the recommendations and suggested opportunities for improvement provided below.

Recommendations:

i. ***DNRW reference the Wivenhoe 2005 spillway upgrade design reports in Safety Condition DS 3.***
ii. ***Design overview reports be developed for Somerset and North Pine dams based on the computation/investigation files available at the Wivenhoe Office to support future Safety Reviews and to ensure that key information is preserved (DNRW must update Safety Condition DS 3 once completed).***

iii. ***DNRW consider adding a requirement to the Safety Conditions for Design Reports and/or computational files to be referenced in Data Books and that future dam upgrades for all SEQWater dams require a Design Report to be prepared and submitted to DNRW within one month of the commencement of construction works as was done for Wivenhoe Stage 1 spillway upgrade.***

iv. DNRW modify DS 4 of the Safety Conditions so that remedial and upgrade works require forwarding of dam safety investigation and design reports at least one month prior to commencement of any construction works as per the Integrated Planning Act or as agreed with DNRW.

v. ***Develop the existing Data Books (currently only an archive reference) into a document that meets the basic requirements of the Queensland Dam Safety Management Guidelines.***

vi. ***SEQWater identify original drawings superseded by recent upgrades and compile a complete set of current 'As Constructed' drawings for each dam.***

vii. ***DNRW modify DS 6 of the Safety Conditions to specify that 'As Constructed' drawings be incorporated in the respective Data Books and those copies of all such drawings and photographic records be securely maintained to ensure future availability.***

viii. DNRW consider incorporating a requirement in the Safety Conditions for DNRW to be provided written notification where a review of SOPs results in no changes.

ix. SEQWater update the SOPs annually.

x. SEQWater look at modifying SOPs 10 & 11 to reflect the frequency of Routine Inspections and seepage monitoring recommended by ANCOLD Guidelines.

xi. The Wivenhoe Dam Safety Conditions should be modified to require a copy of the Comprehensive Inspection reports to be forwarded to DNRW.

xii. All surveillance data prior to 2001 be sourced and made available for future dam safety inspections.

xiii. Final versions of the 2006 Comprehensive Inspections be submitted to DNRW by August 2007.

xiv. SEQWater should review surveillance frequencies in line with ANCOLD Guidelines once the 2006 Comprehensive Inspection reports are finalised.

xv. DNRW to bring forward the date for the next Safety Review to 2015 under DS 12 of the Safety Conditions

xvi. Incorporate inundation and access maps in DNRW's copy of the EAP.

xvii. DNRW remove DS 15 from the Wivenhoe Safety Conditions.

Suggestions:

a. A training record (other than for flood related activities) should be maintained or SOP 17 modified to reflect current practice.

b. ***Consideration be given to incorporating dam safety surveillance as well as dam specific instrumentation training into SOP 17.***

c. ***Triggers for abnormal readings be identified for incorporation into the dam safety database.***

d. Sudden increases in seepage activate EAPs. Consideration should be given to quantifying the increased seepage rates that trigger EAPs or the inclusion of a requirement included for expert review before the EAP is activated.

e. ***Similarly, consideration could be given to introducing triggers for earthquakes based on the magnitudes related to the Modified Mercalli Scale or the seismic equipment at the dam.***

1. Introduction

The aim of the audit is to review the performance of SEQWater against the specific Development Permit Dam Safety Conditions issued by DNRW and the Queensland Dam Safety Management Guidelines (2002) as well as the ANCOLD Dam Safety Management Guidelines (2003) where appropriate.

2. Background

The Development Permit and associated Safety Conditions for the SEQWater dams were issued in 2002. General details for each of SEQWater's referable dams are provided below.

SEQWater is a public company owned by the Queensland Government (20%), Brisbane City Council (45%), and eleven other Local Governments in south east Queensland (35%). These dams provide approximately 85 per cent of the urban water supply to South East Queensland. They also mitigate flood damage to areas above and below the dams and provide recreational and tourist opportunities.

Wivenhoe Dam

Capacity: 1,165,000 ML
Type: Earth & Rockfill Dam
Failure Impact Assessment: Category 2
Referable Dam Reference: 377
Purpose: Urban supply
Completed: 1984
Population at Risk: 244,000

Somerset Dam

Capacity: 380,000 ML
Type: Mass Gravity Concrete Dam
Failure Impact Assessment: Category 2
Referable Dam Reference: 354
Purpose: Urban supply
Completed:1959
Population at Risk: 72(1)
(1) Potential to impact on Wivenhoe in a cascade failure)

North Pine Dam

Capacity: 214,900 ML
Type: Mass concrete Gravity Dam
Failure Impact Assessment: Category 2
Referable Dam Reference: 334
Purpose: Urban supply
Completed:1976
Population at Risk: 838

3. Audit Discussion

The audit commenced with a site inspection of North Pine, Somerset and Wivenhoe dams with Barton Maher (Operations Engineer) along with discussion with operational staff on Thursday 24th May 2007. This was followed up by a review of documentation and discussions on dam safety systems and procedures at SEQWater's office on Thursday 21st June 2007.

The audit is focussed on the Safety Conditions and where appropriate taking into account State and National Dam Safety Guidelines. Observations and comments are provided below based on the format of the Safety Conditions.

3.1 Condition DS 0 - General

This is a general condition requiring the dams to be kept safe at all times. This condition is currently not specified in Safety Conditions for SEQWater dams but will be incorporated in future updates and hence, is covered in the audit for consistency.

Based on a site visit the standard of maintenance was high. The radial gates at Wivenhoe have recently been recoated and the radial gates as well as bulkheads at the other dams are on a 10 year painting program. In many cases wire ropes for gates and bulkheads have been non-destructively tested to verify their condition and in some cases replaced. Gate seals appeared in good condition, equipment regularly exercised, OH&S upgrades undertaken, etc. SunWater are contracted to operate and maintain the dams and appear to be both well resourced and experienced in dams maintenance.

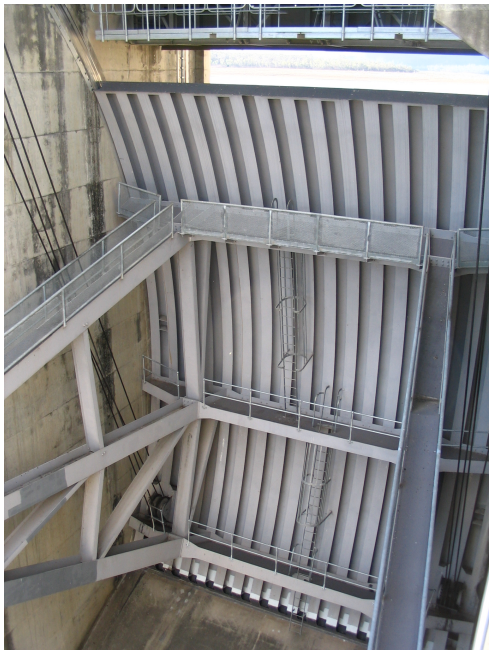
The dams are suitably staffed by specialised operators and supported by extensive documentation as well as experienced contractors (e.g. Wivenhoe – 6 SEQWater Operators, 2 SunWater, North Pine – 4 SEQWater Operators, 2 SunWater, Somerset – 2 SEQWater Operators, 2 SunWater). Note that some of the above SEQWater staff are Rangers who have undertaken dam safety and standby training for backup support.

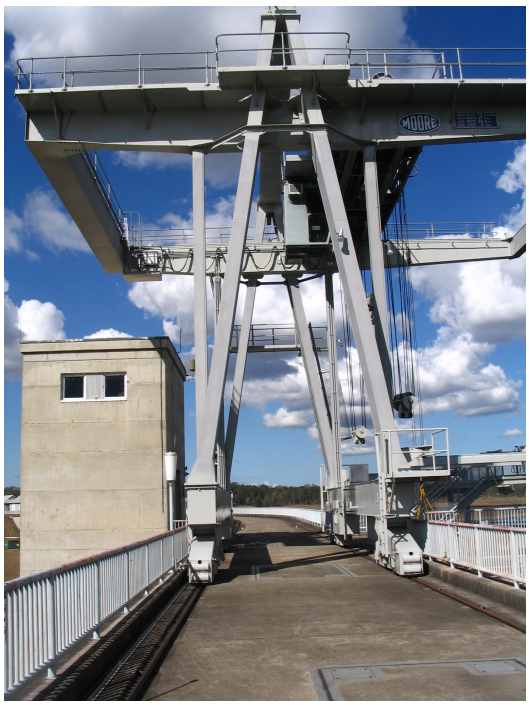
SEQWater have also produced a Dam Safety Management Program which aims to demonstrate their compliance with obligations. It outlines SEQWater's dam safety policy, objectives as well as the elements of their dam safety management program. Combined with this, SEQWater has prepared an actions calendar highlighting tasks, timing and responsibilities to meet regulatory requirements. All the regular reporting requirements for the Safety Conditions are incorporated in these documents. A revised Dam Safety Management Program is submitted to the Board annually for endorsement.

Quality management audits as described in Section 2.3 of the Queensland Dam Safety Management Guidelines are not specifically undertaken by SEQWater.

This is indirectly achieved through Comprehensive Inspections which incorporate a review of documentation as well as surveillance programs combined with the dam safety inspection/review. The 2006 Comprehensive Inspection specifically addressed documentation and the monitoring program adequacy.

Downstream side of a Wivenhoe Dam radial gate.





North Pine Dam gantry crane.

Wivenhoe Dam crest showing winches for raising & lowering radial gates.

3.2 Condition DS 1 - Documentation

This Condition refers to the safe storage of any relevant documentation. Whether or not an organisation has a quality management system in place, the development and maintenance of documentation is critical for review of the ongoing performance and design adequacy of dams. The basic elements of documentation management are addressed in this audit by verifying that systems are in place to manage plans, correspondence and reports.

The filing system for internal/external correspondence is a hard copy based system. Duplicate hard copies are stored at both the Wivenhoe and Brisbane offices. File details are maintained in an index and the files stored in an archive. The movement of files is currently not controlled. SEQWater are aiming to implement an electronic file management system in 2007/8.

A large volume of computational files, field investigation notes, equipment information, drawings and reports relating to the original construction of the dams is located in a store room at the Wivenhoe office. This information is referenced in a Data Book and is further discussed in Section 3.6.

Original dams drawings are catalogued and stored in folders at the Wivenhoe Office. These are scanned and stored on CD for ease of use and backup. Drawings for the recent North Pine and Wivenhoe upgrades are digitised and stored on the network. Superseded drawings should be identified and all current hardcopy and digital versions stored together.

A library of hard copy reports are maintained at SEQWater's Brisbane office. There are no backups provided of these reports other than uncontrolled copies with staff. The Operations Engineer is maintaining an electronic register of key reports that have either been scanned or received in digital form. Assuming that the reports are maintained in a fireproof location (not verified), then this is an excellent system.

3.3 Condition DS 2 - Incidents & Failures

DNRW's file system indicates a magnitude 2.5-3 earthquake occurred on 14/12/02 and a bomb threat on 22/1/03. Discussions with the Operations Engineer, Barton Maher, indicated that he is aware of another threat that was reported directly to Police.

A written report to DNRW for the first two events dated 24th January 2003 exists on DNRW's file. The report marginally exceed the seven days required in the Safety Conditions for the first event. The correspondence did address the actions taken and provided an adequate response to the incident.

No spills have occurred from the storages since 2001 let alone a major flood event. A report on the February 1999 flood events exists as required by the Flood Mitigation manuals.

3.4 Condition DS 3 - Design Report

The Wivenhoe Safety Condition states that the current design report is 'Wivenhoe Dam Design Report Vol 1 Text – September 1995'. Design reports for the stage 1 spillway upgrade completed in 2005 have been submitted to DNRW. These reports are scanned and backed up electronically as well as being located in the SEQWB Brisbane Office library. DNRW should update Condition DS 3 to reference the 2005 design reports.

The Dam Safety Management Program and Safety Conditions indicate a design report is not available for North Pine Dam. According to the Operations Engineer, a brief paper on the original design is available at the Wivenhoe office along with a number of archived computation files (drawer 13 & 14). There have also been a number of specific investigations undertaken with subsequent reports. Given the large amount of information available, for which there is no back up, it would be prudent to compile a design overview report. This should preferably be done before any revised portfolio risk assessment is undertaken.

Similarly, the Dam Safety Management Program and Safety Conditions indicate that no design report is available for Somerset Dam. However, there are archived

design calculation files (drawers 1 & 2) as well as documentation on specific investigations and a design overview report could be compiled.

The requirement for this Safety Condition is unclear. The purpose should be to require/identify key design documentation and ensure it is securely stored. This clause could be enhanced by adding the requirement that a Design Report and/or related computation/investigation records must be referenced in the relevant Data Book as well as securely stored and that any future dam upgrades require a Design Report to be submitted to DNRW within a certain time period (as for DS 4).

Recommendations:

- ***DNRW reference the Wivenhoe 2005 spillway upgrade design reports in Safety Condition DS 3.***
- ***Design overview reports be developed for Somerset and North Pine dams based on the computation/investigation files available at the Wivenhoe Office to support future Safety Reviews and to ensure that key information is preserved (DNRW must update Safety Condition DS 3 once completed.***
- ***DNRW consider adding a requirement to the Safety Conditions for Design Reports and/or computational files to be referenced in Data Books and that future dam upgrades for all SEQWater dams require a Design Report to be prepared and submitted to DNRW within one month of the commencement of construction works as was done for Wivenhoe Stage 1 spillway upgrade.***

3.5 Condition DS 4 - Design & Construction

The purpose of Condition DS 4 is to ensure that any remedial works are consistent with the original design intent for the dam and/or current practice as well as to ensure DNRW are kept informed of proposals.

The Safety Conditions for SEQWater dams currently state that remedial works or dam construction must be in accordance with current engineering practice and accord with listed general arrangement drawings of the dams. It is recommended that DNRW modify the condition to incorporate a requirement for forwarding of dam safety investigation and design reports at least one month prior to commencement of any construction works as per the Integrated Planning Act.

A preliminary portfolio risk assessment was undertaken for SEQWater by SKM & Hydro Tasmania in 2000. It identified the spillway capacity for Wivenhoe was a key risk. Wivenhoe spillway upgrade was completed in 2005 increasing the flood capacity to the equivalent of a 1 in 100,000 AEP event. Given the high PAR, a further upgrade is proposed to achieve a 1 in 143,000 AEP flood capacity to meet ANCOLD Guidelines. The final upgrade was deferred based on risk analysis and the high cost-to-save-a-life relative to other identified portfolio risks and is in accordance with current DNRW Guidelines. An Expert Panel was used to review the design options as well as the risk based approach undertaken. DNRW

partially funded the works and were integrally involved in the consultation/design process.

An unacceptable risk identified in risk assessments was related to the saddle dams for North Pine. This has been largely addressed with works already completed including the installation of filters, toe drainage and supporting fill. Also, Somerset and Wivenhoe spillway gate reliability was improved with the introduction of portable power systems and other minor upgrade works.
Risk assessments followed by peer reviews were completed in 2002 and 2004 for North Pine and Somerset dams respectively. A summary of the portfolio risks are attached in Appendix 2. Societal risk has been reduced by 80% since the upgrade works commenced in 2000.

Investigations are in progress to update the flood risk/capacity for Somerset and North Pine dams. This includes consideration of the spillway gate reliability. The No. 1 saddle dam at North Pine is also being reviewed.

SEQWater are following industry best practice with their approach to risk reduction. A portfolio risk assessment was quickly followed by upgrades addressing the key deficiencies identified. Further detailed investigations are underway to address areas of uncertainty such as flood adequacy (incorporating gate reliability) and saddle dam safety factors. This information will be used to review the portfolio risk assessment in order to prioritise and program future major works.

Recommendation:

- ***DNRW modify DS 4 of the Safety Conditions so that remedial and upgrade works require forwarding of dam safety investigation and design reports at least one month prior to commencement of any construction works as per the Integrated Planning Act or as agreed with DNRW.***

3.6 Condition DS 5 - Data Book

The existing Data Book for Wivenhoe, Somerset and North Pine dams consists of a listing of documents and their location (filing cabinets in a store room at the Wivenhoe office). The Queensland Dam Safety Management Guidelines state that '*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*'.

It is considered that the existing Data Books do not have adequate information to meet the requirements of the above Guideline.

There are no design reports for North Pine and Somerset and 'As Constructed' drawings need to be reviewed to remove those which are redundant. The stored

documents for all three dams are not in a fire-proof room and are in a mixture of formats which would not be readily copied for back up purposes.

As stated in Section 3.4 of this report, an initial priority would appear to be to review the stored computation documents and prepare design overview reports which summarise the key information available for North Pine and Somerset dams. These reports could then be referenced in Data Books and archived in SEQWater's library.

Similarly, the stored construction files on concrete testing, borrow area investigations, soil tests, grouting records, etc, could be summarised in a Construction Report. This report could also be referenced in Data Books and formally archived in the library.

The basic requirements for a Data Book could then be met by incorporating references to recent investigation and risk assessments reports, construction reports on upgrades as well as surveillance information and databases. Annual plots of monitoring data (recently received) and a brief history of the dams including upgrades would cover most of the Queensland Dam Safety Management Guidelines requirements.

Recommendation:

- ***Develop the existing Data Books (currently only an archive reference) into a document that meets the basic requirements of the Queensland Dam Safety Management Guidelines.***

3.7 Condition DS 6 - 'As Constructed' Documentation

The purpose of Condition DS 6 is to ensure that any 'As Constructed' documentation be referenced in appropriate manuals or a Data Book and securely stored. This would include drawings, reports and photographic records.

The current Safety Conditions for all three dams refer to this requirement as 'Not Applicable'.

As outlined in Section 3.2 of this audit report, the original dams drawings are catalogued/scanned and stored in folders at the Wivenhoe Office. Drawings for recent upgrades are separately digitised and stored on the network. Superseded drawings need to be identified and hardcopy and/or digital versions stored as one document set.

Recommendations:

- ***SEQWater identify original drawings superseded by recent upgrades and compile a complete set of current 'As Constructed' drawings for each dam.***

- ***DNRW modify DS 6 of the Safety Conditions to specify that 'As Constructed' drawings be incorporated in the respective Data Books and that copies of all such drawings and photographic records be securely maintained to ensure future availability.***

3.8 Condition DS 7 - Standing Operating Procedures

The Safety Conditions required SOPs to be updated by October each year and a copy or notification of any changes forwarded to DNRW within three months. Typically, Safety Conditions also have a requirement for DNRW to be provided written notification where a review of SOPs results in no changes. DNRW should consider incorporating this requirement in future updates of SEQWater's Safety Conditions.

The SOP review was based on North Pine Dam on the basis that the procedures are similar in format and content for other dams. The latest SOPs are dated December 2004 and were forwarded to DNRW in November 2005. Distribution and revisions are managed as controlled documents.

The SOPs generally cover the requirements in Table 5.2.1.1 of the Queensland Dam Safety Management Guidelines. They do not attempt to cover all potential issues but only those that are relevant and not covered elsewhere in SEQWater documentation. Essentially, this approach appears to match the intention of the Guidelines and meets the needs of SEQWater.

SOP 15 covers equipment exercising and testing. Requirements and frequencies are specified and schedules attached. SunWater have detailed reporting forms which are forwarded to SEQWater once the inspections are complete. By 30 June 2007, SEQWater will have an operational asset management system which will record this information. In future the asset management system will incorporate detailed documentation on how to perform the maintenance/inspections as well as issue work orders for the scheduled tasks. Inspection and maintenance is also covered by the O&M manual. Overall the requirements for equipment exercising and testing are very well documented.

Flood procedures are documented in the 'Manual of Operational Procedures for Flood Releases From North Pine Dam' (as well as for Somerset and Wivenhoe) which is a Gazetted document based on requirements of the Water Act 2000. The current Flood Operations Manual was issued in June 2005. It is currently under review and due for completion in September 2007. SOP 09 outlines responsibilities in relation to the Manual of Operational Procedures for Flood Mitigation for North Pine Dam.

Section 7 of the Operational Procedures for Flood Releases requires a report by 30 September each year to be forwarded to DNRW on the training and state of preparedness of operations personnel. The last report received was dated October 2006. The report indicated that there are three trained flood operation engineers

and two in training. Six trained operators are required for the dams. There are at present thirteen trained operators. There are also twenty trained Data Collectors and a simulation exercise was last undertaken in February 2006. There is a dedicated flood control centre at SunWater's office with a backup facility.

Areas were an SOP either does not appear to meet Guideline requirements or is not adhered to by SEQWater are discussed below.

- SOP 11 refers to Routine Inspections and requires weekly inspections for the concrete dam. As a High Hazard dam, this should be daily to three times weekly for North Pine Dam under ANCOLD Guidelines. SEQWater are aware of this issue and are considering the resourcing options to increase the surveillance frequency.

- Similarly, SOP 10 does not meet ANCOLD Guidelines where it specifies weekly seepage measurement compared to the ANCOLD Guidelines recommendation of daily to three times weekly.

- SOP 17 refers to training. It outlines specific internal training requirements and specifies that records to be maintained in a training file. A flood preparedness report is forwarded annually to DNRW from SunWater. No training file is currently maintained for non flood related activities and there is no instrumentation/dam safety training requirement or industry based certificate training such as the DNRW Dam Safety course.

Overall SEQWater's SOPs address the requirements of both the Safety Conditions and the Queensland Dam Safety Management Guidelines. As well as minor non conformances, a number of potential improvements have been identified below for consideration when the SOPs are next revised.

Recommendations:

- ***DNRW consider incorporating a requirement in the Safety Conditions for DNRW to be provided written notification where a review of SOPs results in no changes.***
- ***SEQWater update the SOPs annually.***
- ***SEQWater look at modifying SOPs 10 & 11 to reflect the frequency of Routine Inspections and seepage monitoring recommended by ANCOLD Guidelines.***

Suggestions:

- ***A training record (possibly combined with flood related training records) should be maintained or SOP 17 modified to reflect current practice.***
- ***Consideration be given to incorporating dam safety surveillance as well as dam specific instrumentation training into SOP 17.***

3.9 Condition DS 8 - Detailed O&M Manuals

Updates are required for O&M manuals by October annually under the Safety Conditions. SEQWater's manuals have not been updated for a number of years and are currently being rewritten in a modified format. The new format is to be based upon systems (e.g. radial gates, crane & bulkheads, intake/outlet, etc). The new manuals for all three dams are not expected to be completed until 2008. It is anticipated that annual updates will be practical in future once the current rewrite is completed as only minor modifications should be required. Previously three or four manuals required updating if say the cone valve was modified. In future only one manual would require modification.

Manuals are currently available at dam sites in hard copy form. Hard and digital copies of the manuals will be available once the update is completed. OH&S and environmental impacts associated with activities will be taken into consideration with procedures. Operational staff are being consulted in the rewrite to enable their personnel knowledge to be incorporated and to ensure procedures are accurate and feasible.

Comments on some key aspects of the revised manuals are provided as follows:

- conditioning monitoring, maintenance and exercising requirements are being outlined in six and twelve monthly programs in the manuals being updated. The requirements are supported by specific procedures and instructions;
- the manuals provide descriptions and supporting information such as rating tables for surveillance instrumentation. Monitoring frequencies are outlined in SOPs as previously discussed;
- forms for condition inspections and surveillance monitoring are provided by the maintenance contractor (SunWater). The need for these forms will be superseded once the asset management system is up and running later this year;
- hyperlinks are incorporated for relevant internal SEQWater documentation and manufacturer manuals; and
- information is being incorporated on the availability of replacement parts and suppliers for items of equipment that are no longer available.

The manuals under revision will meet the requirements of the Queensland Dam Safety Management Guidelines. It is expected that annual updates required by the Safety Conditions will be achievable in future once the revisions in progress are completed.

3.10 Condition DS 9 - Special Inspections

No Special Inspections have been required by DNRW since the Safety Conditions were applied or noted in DNRW's files.

3.11 Condition DS 10 - Annual Periodic Inspections

With the exception of 2006, Annual Inspections have been undertaken as required under the Safety Conditions. A Comprehensive Inspection was required in 2005, however, this was deferred to 2006 due mainly to the spillway fuse plug upgrade activity and associated construction site restrictions.

The 2004 Annual Inspection was briefly reviewed and found to be lacking in some areas of the Queensland Dam Safety Management Guidelines such as the review and analysis of surveillance data as well as previous recommendations. Earlier Annual Inspection reports were reportedly of a higher standard. SEQWater is seeking to improve both its forms and brief for undertaking Annual Inspections.

A number of dambreak assessments have been undertaken for Wivenhoe Dam in recent years with the high PAR and spillway upgrades. The most recent was completed by the Department of Commerce Dams & Civil Group last year as part of the Comprehensive Inspection. Somerset and North Pine dams were Deemed on 21/3/01 as Category 2 dams. FIAs for these dams were not reviewed as part of this audit.

SEQWater generally undertake Annual (Periodic) Inspections in accordance with the Queensland Dam Safety Management Guidelines and hence the Safety Conditions. The lack of inspections in 2005 were largely due to upgrade activities at the time and areas for improvement noted from the 2004 reports are not typically repeated in other Annual Inspection reports received by SEQWater.

3.12 Condition DS 11 - Comprehensive Inspections

The Safety Conditions specify that Comprehensive Inspections are required by October 2005 for all three SEQWater dams. These inspections were undertaken in mid 2006. Draft reports have been submitted but these are yet to be finalised by the consultant.

The Wivenhoe Safety Conditions do not require a copy of the Comprehensive Inspection Report to be submitted to DNRW, however, it is a requirement for Somerset and North Pine. The Wivenhoe Safety Conditions should be modified for consistency to require a copy of the Comprehensive Inspection reports to be forwarded to DNRW.

For North Pine Dam, a ‘High A’ Hazard dam including the saddle dams, the following surveillance frequencies apply:

- Routine Inspections twice weekly

- Seepage continuously monitored by a flow meter in the concrete dam and twice weekly for embankments
- Piezometers weekly
- Deformation survey annually (by SunWater)
- Continuous Seismic

With the exception of seepage, the above inspection frequencies meet ANCOLD Guidelines. A review of the Hazard Category and monitoring frequency is being undertaken as part of the 2006 Comprehensive Inspection report (yet to be finalised).

Hard copies of the weekly surveillance records are forwarded to the Operations Engineer at SEQWater from SunWater who are contracted to undertake dam safety surveillance. SunWater maintain the surveillance database. There are no limits built into the database at this time to assist in detection of errors or unacceptably high readings. A spreadsheet of the surveillance data is forwarded to SEQWater's Operations Engineer monthly. SEQWater have developed plots to highlight data trends for piezometers and deformation survey. The data and associated plots are reviewed by the surveillance consultant during Annual Inspections.

Data prior to 2001 has not been available for recent Annual or Comprehensive inspections although some earlier seepage and uplift gauge data were sighted from a 2003 report. Hard copy records of earlier data are being sourced from SunWater for future inspections.

A review of the draft 2006 North Pine Dam Comprehensive Inspection indicated that the report addressed the requirements of Safety Conditions and Queensland Dam Safety Guidelines. Whilst still incomplete, the draft report appears to appropriately cover the following issues:

- previous Annual Inspection reports and actions;
- EAP, Data Book, SOPs and O&M manual documentation;
- surveillance program;
- analysis of monitoring data; and
- dam safety against current Guidelines.

Recommendations:

- ***The Wivenhoe Dam Safety Conditions should be modified to require a copy of the Comprehensive Inspection reports to be forwarded to DNRW.***
- ***All surveillance data prior to 2001 be sourced and made available for future dam safety inspections.***
- ***Final versions of the 2006 Comprehensive Inspections be submitted to DNRW by August 2007.***
- ***SEQWater should review surveillance frequencies in line with ANCOLD Guidelines once the 2006 Comprehensive Inspection reports are finalised.***

Suggestion:

- ***Triggers for abnormal readings be identified for incorporation into the dam safety database.***

3.13 Condition DS 12 - Safety Review

According to the Safety Conditions, the next Safety Reviews are due in 2017 for Wivenhoe and 2015 for Somerset and North Pine dams. The above dates are twenty years after the last Safety Reviews were undertaken for each dam.

The Comprehensive Inspections are next due in 2010 and 2015 for all dams. The Safety Review would substitute for the Somerset and North Pine Comprehensive Inspections in 2015. In consultation with SEQWater, the timing of the 2017 Wivenhoe Safety Review and Comprehensive Inspections specified in the Safety Conditions should be reviewed to avoid incurring unnecessary costs. Barton Maher has indicated a preference to have the next Wivenhoe Safety Review bought forward to 2015 in place of the Comprehensive Inspection to minimise costs.

The most recent North Pine Dam Safety Review was completed in 1995 by GHD. Design criteria were reviewed looking at issues such as stability (including earthquake), concrete strength, structural performance of the gates, surveillance program and data analysis. Deficiencies were noted including:

- at FSL and under PMF conditions the tensile stresses in the upstream face of the spillway section are exceeded; and
- under the maximum design earthquake the overflow and non-overflow sections of the dam do not meet ANCOLD Guidelines and the gates are overstressed.

Drilling was recommended to verify some of the foundation material parameters if design and construction records were not found. The installation of piezometers and material testing were undertaken in 1997. Dispersive soils were detected in the samples and a follow up report in 1998 recommended the installation of filters on Saddle Dams 1 & 2. A preliminary design report was prepared in 1999 and the saddle dam upgrades completed in 2002.

The issues raised in the Safety Review have been progressively addressed with the status of all recommendations summarised in the Dam Safety Management Program. In some cases the recommendations have not been accepted following a peer review.

Seepage and uplift surveillance data were appropriately reviewed.

The 1995 and 1997 Safety Reviews for the SEQWater dams met the requirements of the ANCOLD Guidelines on Dam Safety Management (1994) which were the

appropriate guidelines at the time. The subsequent follow up investigations, upgrade works and ongoing review of progress are excellent.

Recommendation:

- ***DNRW to bring forward the date for the next Safety Review to 2015 under DS 12 of the Safety Conditions.***

3.14 Condition DS 13 - Emergency Action Plans & Event Reports

The Safety Conditions require an EAP conforming with the Queensland Dam Safety Management Guidelines, contact details to be updated by October annually, a full review of the document in 2007 and DNRW to be forwarded updates of any changes.

Regular annual updates of the EAP have been undertaken since 1999 and distributed to appropriate agencies. At the time of the audit discussions, a full review was being finalised.

Section 12.7 of EAP states reviews are to be undertaken at intervals not exceeding two years. SOP 4.1-03 states that the contact list is to be updated each September. These SEQWater requirements are similar to those of the Safety Conditions.

The EAPs have been authorised and distributed as controlled copies to agencies identified in the Safety Conditions.

The Contact List is well formatted with prioritised contacts for both during and after working hours. Communication consists of landline, mobiles and radios. Emergency loss of communication training is undertaken annually. With communications down during a flood, the operators maintain water levels by storage gauges only (no routing).

Under Clause 497 of the Water Act 2000, manuals for 'Operational Procedures for Flood Releases from Wivenhoe/Somerset/North Pine' dams are required to be prepared and forwarded to DNRW. The Flood manuals were last updated in April 2007. Whilst there are no guidelines to audit against, the manuals were briefly reviewed. The manuals are controlled documents, identify responsibilities and training requirements, prioritise objectives and provide adequate information to assess flood magnitudes and release arrangements. Routing is supported by a flood model into which real time data is fed from the rainfall (80 No.) and streamflow (40 No.) sites located throughout the catchments. Critical gauges are backed up with some redundancy in radio paths. Direction is provided on communication protocols and review procedures. The Flood Manuals are linked to EAPs and initiated whenever a spillway discharge event is deemed likely. The EAPs outlines responsibilities for when flood triggers are reached.

A flood engineer is on 24 hour call. The flood centre is in the Hall Chadwick Centre (Floor 9, 120 Edward Street) with a backup at Mineral House. The

facilities at these centres were not reviewed as part of the SEQWater dam safety audit. It is proposed instead that these facilities be incorporated in the SunWater dam safety audit.

Overall the EAPs and Flood manuals are well formatted and meet the requirements of the Queensland Dam Safety Management Guidelines and hence the Safety Conditions. The following comments are provided:

- The EAPs requires DNRW to be notified when flooding looks likely, even before spillway discharges occur. Seems reasonable for these dams.

- Sudden increases in seepage require activation of the EAPs (Sect 10.4). Should the increased seepage rates to trigger the EAP be quantified or the inclusion of a requirement included for expert review before the EAP is activated?

- SEQWater have two strong motion recorders for measuring earthquake accelerations at each dam (toe and crest) as well as six seismographs in catchment areas. A lot of the equipment had reached the end of its useful life and was replaced in 2000. SEQWater currently have a staff member who undertakes basic analysis of any earthquake events. The network is also connected to ES&S and Geoscience for support. It is worth considering introducing an EAP trigger for earthquakes? This could relate to a magnitude based on the Modified Mercalli Scale and or the instrumentation.

- Inundation and access maps are not included in the EAPs provided to DNRW. Copies of inundation maps have been forwarded to DNRW but could not be found at the time of this audit. As other Authorities provide this information to DNRW and given that they were unable to be located, it would seem appropriate to incorporate inundation maps in the DNRW copy of the EAPs.

As mentioned in Section 3.3, there was a local earthquake recorded on 14th December 2002. It is not clear if this earthquake was felt at the storage which is the requirement to initiate the EAP. An incident report was subsequently submitted to DNRW.

Annual exercises are suggested in Guidelines for operational staff and at least 5 yearly with other authorities involved. SEQWater undertake annual Standby operator training, loss of communication exercises and desktop flood exercises. The last flood training exercise with SunWater was undertaken in 2006.

Recommendation:

- ***Incorporate inundation and access maps in DNRW's copy of the EAP.***

Suggestions:

- ***Sudden increases in seepage activate EAPs. Consideration should be given to quantifying the increased seepage rates that trigger EAPs or***

the inclusion of a requirement included for expert review before the EAP is activated.

- ***Similarly, consideration could be given to introducing triggers for earthquakes based on the magnitudes related to the Modified Mercalli Scale or the seismic equipment at the dam.***

3.15 Condition DS 14 - Decommissioning

No decommissioning plan has been required, hence, there is nothing to audit at this time.

3.16 Condition DS 15 - Spillway Investigation

The Wivenhoe Dam Safety Conditions require the preparation of a revised PMF estimate based on the latest Bureau of Meteorology generalised method as well as a revised spillway capacity before January 2003.

The spillway capacity was upgraded to pass the 1 in 100,000 Annual Exceedance Probability (AEP) event with works completed in late 2005. An auxiliary spillway to pass the PMF (1 in 143,000 AEP) event is the subject of prioritisation based on risk assessment.

Condition DS 15 of the Safety Conditions would appear to have been superseded and has been met by SEQWater.

Recommendation:

- ***DNRW remove DS 15 from the Wivenhoe Safety Conditions.***

4. References

- DNRW File 130/334, 130/354 & 130/377
- The Dam Safety Management Program for Wivenhoe, Somerset, North Pine Dams – April 2007
- North Pine Dam Emergency Action Plan -Dec 2005
- Somerset Dam Emergency Action Plan -Dec 2005
- Wivenhoe Dam Emergency Action Plan -Dec 2005

- North Pine Dam Standing Operating Procedures - Dec 2004
- North Pine Dam Safety Review (Sept 1995)
- Somerset Safety Review (Sept 1995)
- Wivenhoe Safety Review (1996)
- Design Discharges & Downstream Impacts of the Wivenhoe Dam Upgrade – 2004
- Draft North Pine Dam Comprehensive Inspection Report – July 2006 (NSW Dept of Commerce)
- Draft Somerset Dam Comprehensive Inspection Report – July 2006 (NSW Dept of Commerce)
- Draft Wivenhoe Dam Comprehensive Inspection Report – July 2006 (NSW Dept of Commerce)
- Repairs to North Pine Saddle Dams & Right Abutment, Preliminary Design Report – 1999 (GHD)
- Geotechnical Investigations, North Pine Dam - 1998 (GHD)
- Geotechnical Investigations, North Pine Dam - 1997 (GHD)
- Manual of Operational Procedures for Flood Releases From North Pine Dam – July 2002
- North Pine Dam Operation & Maintenance Manual – 2002 (SEQWater)
- Wivenhoe Data Book – 2000 (SEQWater)
- Safety Conditions were issued for SEQ Water dams in July 2002.

APPENDIX 1

SAFETY CONDITIONS

APPENDIX 2

Portfolio Risk

SEQWater Portfolio Risk Summary

(as at 25 July 2007)

Dam	Loading	Probability Of Failure	Loss of Life	Owner Costs	Third Party Costs	Risk Cost Total	Life Safety
Wivenhoe Dam							
	Flood	7.00E-06	112	58.0	25,394.0	1.78E+05	7.84E-04
	Earthquake	5.00E-06	36	36.0	3,650.0	1.84E+04	1.80E-04
	Static	1.00E-06	77	36.0	3,650.0	3.69E+03	7.70E-05
	Total	1.30E-05		130.0	32,694.0	2.00E+05	1.04E-03
Somerset Dam							
	Flood	2.22E-06		18.0	1.0	4.22E+01	0.00E+00
	Earthquake	1.00E-06		2.0	1.0	3.00E+00	0.00E+00
	Static			2.0		0.00E+00	0.00E+00
	Total	3.22E-06		22.0	2.0	4.52E+01	0.00E+00
North Pine Dam							
	Flood	1.58E-06	13	53.0	752	1.27E+03	2.05E-05
	Earthquake	4.59E-06	1	2.0	120	5.60E+02	4.59E-06
	Static	1.00E-05	5	2.0	41	4.30E+02	5.00E-05
	Total	1.62E-05		57.0	913	2.26E+03	7.51E-05
	Flood					0.00E+00	0.00E+00
	Earthquake					0.00E+00	0.00E+00
	Static					0.00E+00	0.00E+00
	Total	0.00E+00		0	0	0.00E+00	0.00E+00