

Date : 5/09/2019 10:16:05 AM

From : s.49 - CTPI

To : "COWLEY-GRIMMOND Jarrod"

Cc : "Lisa Dalton"

Subject : Draft Paradise DAM Briefing Note

Attachment : PRODUCTION-#2472491-v3-20190903 - SHM brief for noting -

_Update_on_Paradise_Dam_Revised_Risk_Assessment.docx;image296881.png;image923402.png;image610979.png;image016820.png;image480639.jpg;

Jarrood

Further to our chat earlier yesterday and your conversation with s.49 last night I attach the draft Briefing Note.

Any questions please give me a call.

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North,
Level 9, 515 St Pauls
Terrace, Fortitude Valley,
Queensland 4006

sunwater.com.au



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SHAREHOLDING MINISTERS BRIEF FOR NOTING

FROM: s.49 - CTPI

DATE: 5 September 2019

SUBJECT: Update regarding Paradise Dam Revised Risk Assessment

Recommendation

That the Shareholding Ministers and departmental representatives **NOTE:**

- the revised dam stability assessment for Paradise Dam has been completed and should an event similar event to the 2013 flood of record occur, the stability of the dam is considered marginal and may fail, resulting in potential loss of life and property. The Paradise Dam Emergency Action Plan (EAP) would respond to this scenario by triggering the evacuation of significant numbers of Bundaberg and downstream residents
- Sunwater’s preliminary recommendation is to proceed with an accelerated delivery of early stage (emergency) risk reduction works, comprising initial lowering of the spillway by a minimum of 5 metres with a strong preference to lower the spillway by 10 metres to achieve improved early risk reduction outcomes (note however a 10-metre lowering will preclude the Detailed Business Case (DBC) option for full upgrade works to maintain the current full supply level)
- that emergency risk reduction works are required in advance of the full Dam Improvement Project (DIP), as further works will be required (second stage) to achieve an acceptable risk reduction, given the dam is the highest rated risk and significantly above the limit of tolerability
- indicative preliminary cost estimates for emergency risk reduction works are in the order s.49 - CTPI s.49 - CTPI and Sunwater’s recommendation is to proceed with this scope outside of the Building Queensland Business Case Framework, though Building Queensland will continue to lead and expedite the DBC for the full DIP (required for the second stage)
- the emergency risk reduction work options need to be workshopped on an urgent basis with all relevant Government stakeholders to review the evaluation of early risk reduction measures and agree on the process and scope for any early stage works (extent of lowering), including potential approval exemptions, to facilitate these works and the scope of the DBC.

Paradise Dam Safety Risk

- As advised on 1 March 2019 (refer to Sunwater briefing note #2414975), Sunwater’s design consultant reviewed the dam stability for Paradise Dam and assessed a potential significant increased risk of dam failure, though pending further investigations and review
- Further review has now been completed (including onsite geotechnical investigations, revised assessment by Sunwater’s consultant, engagement of a Technical Review Panel (with 6 national and international experts), and findings from the expert review workshop on 27 and 28 August 2019
- The review has confirmed Paradise Dam’s revised risk profile and that, should a similar event to that of the 2013 flood of record occur, the dam is at, or close to, marginal stability and may fail

SUNWATER

Briefing Officer: s.49 - CTPI
 Telephone:
 File Ref: Doc# 2472491

CONSULTATION

Approved: s.49 - CTPI
 Date: 5 September 2019

DNRME: _____
 Treasury: _____
 Date: _____

- Sunwater’s EAP will trigger the evacuation of significant numbers of Bundaberg and downstream residents if flood levels approach, or are forecast to reach, the 2013 peak flood level. The current EAP will generate an Emergency Alert message (sent by State Disaster Groups at Kedron in conjunction with the LDMG or Council). This has been in place since March 2019. To predict flood levels in advance, Sunwater maintains a flood forecasting model that will identify flood levels based on rainfall accumulations throughout the Burnett catchment. In addition, early advice is issued to residents in the immediate downstream reaches of the river

Sunwater’s Response to Paradise Dam Safety Risk

- In direct response to the confirmed Paradise Dam safety risk, Sunwater is:
 - undertaking additional specific flood hazard impact mapping and engagement with the Bureau flood warning service to review evacuation triggers and other actions currently being planned
 - reviewing emergency procedures for Paradise Dam with Bundaberg Regional Council and the Local Disaster Management Group (LDMG) prior to the 2019/2020 wet season – noting that initial briefings were carried out in March 2019
 - preparing an engagement campaign in conjunction with Bundaberg Regional Council once the initial scope and timing of mitigation works is agreed. This is to ensure we advise publicly of the issue and the actions being undertaken concurrently. Bundaberg Regional Council (BRC) has a publicly available flood mapping tool that we would aim to utilise and leverage from previous engagement conducted by BRC on community flood preparations
 - assessing options to identify ways to reduce dam safety risks in line with good practice, community expectations, and legal and dam safety obligations, including:
 - a) Fast-tracking early stage emergency works to lower the spillway crest level by 10 metres, followed by further improvement works as required (including anchoring and dam strengthening works, as per the current DBC for the full Paradise Dam Improvement project scope) – though this option will render returning the spillway level to its current full supply volume impractical (one of the options considered in the Business Case)
 - b) Fast-tracking early stage emergency works to partially lower the spillway crest level by 5 metres, followed by further improvement works as required – this would allow both Detailed Business Case options to be considered
 - c) Accelerating the current DBC process and full project delivery as a single stage (though constrained by current project processes and approvals)
 - reviewing project approval requirements, emergency powers, and possible exemptions to facilitate early stage or accelerated work, for discussion with the Department of Natural Resources, Mines and Energy (DNRME)
 - updating the Paradise Dam Stakeholder Management Plan and developing a Communication Action Plan to outline how key stakeholders (eg. community, customers, local agencies, LDMG) will be informed and engaged regarding the dam’s risk profile and any early stage risk reduction measures.
- In order to achieve risk reduction benefits as soon as reasonably practical (in accordance with Sunwater’s Dam Safety Policy) and to discharge our legal duty of care, the early stage works in scenarios a) and b) above are recommended to proceed outside of the Building Queensland Business Case Framework (the estimated cost for these works are of the order of s.49 - CTPI), and seeking exemptions and/or expedited project approvals as applicable

- Project approvals that may apply for early stage works include:
 - Development Application for a referable dam (impact assessable) (*Planning Act 2016*, and *Water Supply (Safety and Reliability) Act 2008*),
 - Waterway Barrier Works (*Fisheries Act 1994*),
 - Clearing of protected plans (*Nature Conservation Act 1992*) for left bank access,
 - Species Management Program for impacting animal breeding places including turtles, platypus, lungfish (*Nature Conservation Act 1992*) for water releases,
 - Interim Program approval (*Water Act 2000*) to lower storage level, and
 - possible impact on Matters of National Environmental Significance (*Environment Protection and Biodiversity Conservation Act 1999*)
- If project approvals are to be expedited, design and procurement activities can proceed through late 2019 to potentially enable award and commencement of access works early 2020 (ramp and bridge works from abutments to spillway crest), though these works will be impacted and limited by wet weather. Construction works to follow to lower the spillway (strengthen training walls, lowering of the intake tower, demolition of spillway crest, lowering the spillway, and capping the lowered crest) to an interim extent and level in the dry season by late 2020, and completion by late 2021
- The remaining improvement works (second stage) are proposed to be undertaken as per current DBC processes and full project approvals, for completion by end 2025
- Note that early stage emergency works (spillway lowering) will not achieve full compliance for acceptable risk reduction (being below the Australian National Committee on Large Dams (ANCOLD) limit of tolerability and considering Guideline principles for As Low as Reasonably Practical), though will achieve significant risk reduction benefits as an interim measure
- It is further noted that current assessment for the full upgrade option (Option 2 from Preliminary Business case, refer to Background below) is that it may not be practical to implement sufficient improvement scope to achieve an acceptable risk reduction outcome. It is therefore likely that some permanent lowering of the spillway level may be required as a minimum (less than 10 metres)
- In addition to options above, temporary operational lowering of the full supply level of the dam has also been assessed, though this indicated it would provide negligible risk reduction benefits on its own due to the size of Paradise Dam and the volume of water during an event the size of the 2013 flood (though this may still be implemented)
- The outcomes of any decision to implement early stage risk reduction measures will impact on the full Paradise Dam Improvement Project scope which is currently subject to a Building Queensland-led Detailed Business Case – Sunwater has advised Building Queensland, and will work with them to determine how best to progress
- Sunwater is seeking to confirm early stage risk reduction measures by late September 2019, following a proposed options workshop with DNRME and Treasury.

Detailed Business Case

- s.49 - CTPI

• s.49 - CTPI
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Date : 25/09/2019 5:05:05 PM

From : "COWLEY-GRIMMOND Jarrod"

To : s.49 - CTPI

Cc :

Subject : Paradise DIP - Decisions and Timing

Attachment : 190922_History of Paradise Dam Formatted.docx;image001.png;image002.jpg;

Hi s.49 - CTPI

I have been asked to confirm a few dates for the Paradise Dam Dip Program. I have the timeline that s.49 provided on Monday. From that document it seems to me that the key dates are:

- June 2016 – Stage 1 of DIP program commenced including strengthening monoliths and additional protection to the spillway
- August 2017 – Stage 1 works completed
- May 2018 – PBC completed for Stage 2 of the DIP Program (when did this commence?)
- 2018 ??? preparatory works for Stage 2 DBC commenced (is there a more specific date?)

Can you advise:

- When did sunwater seek approval to commence the DBC?
- When did sunwater receive approval to commence the DBC?
- when did Sunwater commence the Detailed Business Case?

Thanks

Jarrod



Jarrod Cowley-Grimmond

Director – Economics and Governance

Water Supply Business Unit

Natural Resources Division

Department of Natural Resources, Mines and Energy

P: 0733305061 M: s.49 - CTPI

E: jarrod.cowley-grimmond@dnrme.qld.gov.au

A: level 8 1 William Street, Brisbane QLD 4001

W: www.dnrme.qld.gov.au



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History of Paradise Dam

Date	Issue	Action/Overview
November 2005	Paradise Dam construction complete at cost of [redacted]	
16 December 2005	Burnett Water Pty Ltd became a subsidiary company of Sunwater. Paradise Dam now owned and operated by Sunwater.	
March 2010	Paradise Dam filled for the first time	
December 2010 – April 2011	Paradise Dam inundated by extreme weather and three major flood events: <ul style="list-style-type: none"> December 2010 – peak above crest 5.96 metres (2nd) – first spill event January 2011 – peak above crest 4.23 metres (3rd) March 2011 – peak above crest 3.87 metres (4th) Only minor structural damage.	No Action Required
January 2013	Paradise Dam damaged by Tropical Cyclone Oswald – extensive scour downstream of the primary spillway compounding damage from a prior 2011 flood event: <ul style="list-style-type: none"> Flood of record – peak above crest 8.65 metres (1st) At the peak of the flood approximately 1,425,600 ML (4.6 times the dam’s capacity) was assessed as flowing over the spillway each day 	<p>March 2013: Urgent repair work undertaken at cost of [redacted] (including Phase 1 involved undertaking emergency repairs to enable the dissipator to withstand a late 2013 season flood event. These works were completed in June 2013. [redacted] and Phase 2 to mitigate any immediate path to failure. [redacted] and included downstream scour holes, dissipator sill and rock foundations.</p> <p>December 2013: Further urgent repair work undertaken at a cost of [redacted] (effectively CRA Phase 4A to dissipator slab to provide immunity for a flood loading equivalent to that experienced in the January 2013 flood) from the DSR being undertaken.</p> <p>Total Cost: [redacted]</p>
March 2013 to Oct 2014	SunWater brought forward the comprehensive dam safety review of Paradise Dam, originally scheduled for 2025, This Report confirmed that the dam is safe under normal operating conditions and	The Paradise Dam Full Dam Safety Review submitted to Regulator on 21 Oct '14 - effectively Phase 3 of CRA The CRA also assessed a range of options

	can safely pass a flood of similar magnitude to the 2013 event, which is the largest flood on record.	and costs to mitigate potential dam safety risks.
22 August 2013	Paradise Dam Review – Public Works NSW Water Solutions	Paradise Dam – Report for the Review of Dam Safety Management Actions (the Report) – 29 August 2013
October 2014 to February 2015	<p>Updated Interim Comprehensive Risk Assessment (CRA) completed and submitted to the Regulator</p> <p>The CRA placed the dam above the Australian National Committee on Large Dams (ANCOLD) Guideline Limit of Tolerability for failure – due to the risk of downstream scouring undermining the integrity of the spillway structure.</p>	CRA involved two stages for DIP with works and business case submitted in April 2015 to the Regulator and approved by the Sunwater Board
February 2015	<p>Paradise Dam inundated by extreme weather and spilled:</p> <ul style="list-style-type: none"> February 2015 – peak above crest 2.58 metres (5th) 	
May 2015	SunWater commenced detailed planning and design to undertake Stage 2 works that will strengthen the toe of two sections of the primary spillway.	
June 2015	Other minor ancillary repairs of CRA Phase 2 works (such as handrails, electrical works etc).	Completed
June 2016	CRA involved Stage 1 DIP planning for works to be undertaken which commenced in April 2016 and completed in 2017 to strengthen monoliths D&K and completed an additional section of concrete protection to the base of the primary spillway involving installation of anchor bars and reinforcement of concrete	August 2017: Completed Stage 1 improvement works at a total cost of s.49 - CTPI
2015 to December 2016	Improved EAP requirements as part of studies and CRA including emergency response planning in liaison with local and district disaster management groups	Completed
May 2018	Preliminary Business Case for further improvement works (Stage 2) completed. The study assessed factors including life cycle costs, current and future water demand and environmental factors to determine the best	<p>Completed PBC Stage 2</p> <p><i>(Option considered included the construction of a new dam downstream of the existing dam site, upgrading of existing Paradise Dam</i></p>

	engineering design options to take forward for assessment in the DBC	<i>infrastructure, a reduction in capacity of the existing dam and decommissioning of the dam)</i>
October 2018	Expression of Interest (EOI) process for water allocation from Paradise Dam tested demand and increased water sold to 20 per cent (additional 12,000ML)	Input into DBC demand study
2018	Sunwater commenced preparatory works and studies for the Paradise Dam Spillway DIP Stage 2 and made recommendation to State for the DBC to include analysis of full upgrade of the existing dam and a potential reduction in capacity of the existing dam by lowering the spillway Early indicative costs s.49 - CTPI	
October 2018 – February 2019	To develop the design basis for the options being considered in the Detailed Business Case, GHD reviewed the stability and shear strength of the dam and spillway.	
Late February 2019	Initial findings indicated a second major risk (in addition to the risk of downstream scouring identified in the 2016 CRA and DSR) regarding the shear strength and stability of the concrete that was used to construct the dam and spillway, which may lead to a failure.	
xxx	State approved BQ to lead PDIP DBC	DBC includes review and planning of two preferred options from the preliminary business case, with targeted completion of DBC late 2020
March- late-August 2019	Further investigations undertaken and completed, including independent technical review, confirming that if an event like the 2013 flood of record occur, the stability of the dam is considered marginal and may fail.	

Date : 25/09/2019 4:52:01 PM

From : "COWLEY-GRIMMOND Jarrod"

To : "'Adam Obeid"' , "ZERBA Bernadette"

Subject : RE: paradise-dam-review (1).pdf

Attachment : 190922_History of Paradise Dam Formatted.docx;Paradise Dam Review - Public Works NSW Water Solutions.docx;image001.png;image002.jpg;

Hi Adam, yes that is correct. See attached information from Sunwater which was sent to the CoS on Monday.

The report did not recommend the lowering of the dam wall as in 2013 it was much too early in the DIP program for that to be considered. The report was focussed on the response to the 2013 event and not on the broader dam safety issue, as a recently constructed dam it would not have been up for a dam improvement review for some time, and Sunwater has advised that their original timing for the review was 2025, but it was brought forward due to the 2013 event

From my reading of report and Sunwater's response to the recommendations here are the phases:

- Phase One – Urgent Repair Works to dissipator (completed March 2013)
- Phase Two – Urgent Repair Works to downstream scour (completed June 2013)
- Phase Three – Comprehensive Risk Assessment submitted to dam safety regulator October 2014.

There is also the two stages of the Dam Safety Program which were

Stage 1 was the works done in phase one and two plus works to strengthen to toe of the dam – this was completed in 2017

Stage 2 – the remaining DIP program where the Preliminary Business Case was prepared in May 2018 and shortlisted the 10 metre lowering and the full supply level option. It did consider others options such as decommissioning and a 17 metre lowering but they were ruled out for various reasons.

Happy to provide further background

From: Adam Obeid <Adam.Obeid@ministerial.qld.gov.au>

Sent: Wednesday, 25 September 2019 4:30 PM

To: ZERBA Bernadette; COWLEY-GRIMMOND Jarrod

Subject: RE: paradise-dam-review (1).pdf

The report only refers to the different phases i.e. phase 1, 2 and 3 as P1, P2 and P3. It does not include them and does not include reference to the lowering of the dam wall.

Adam

From: ZERBA Bernadette <Bernadette.Zerba@dnrme.qld.gov.au>

Sent: Wednesday, 25 September 2019 4:21 PM

To: Adam Obeid <Adam.Obeid@ministerial.qld.gov.au>; COWLEY-GRIMMOND Jarrod <Jarrod.Cowley-Grimmond@dnrme.qld.gov.au>

Subject: RE: paradise-dam-review (1).pdf

Sorry just saw this. Yes it is.

Kind regards



Bernadette Zerba

Executive Director

Water Supply, Natural Resources Division

Department of Natural Resources, Mines and Energy

P: (07) 3137 4265 M: s.49 - CTPI

E: bernadette.zerba@dnrme.qld.gov.au

A: Level 3, 1 William Street, Brisbane QLD 4000

W: www.dnrme.qld.gov.au



From: Adam Obeid <Adam.Obeid@ministerial.qld.gov.au>

Sent: Wednesday, 25 September 2019 3:39 PM

To: COWLEY-GRIMMOND Jarrod; ZERBA Bernadette

Subject: RE: paradise-dam-review (1).pdf

Bernadette,

Is this the report?
19-132

Adam

From: COWLEY-GRIMMOND Jarrod <Jarrod.Cowley-Grimmond@dnrme.qld.gov.au>
Sent: Wednesday, 25 September 2019 3:20 PM
To: Adam Obeid <Adam.Obeid@ministerial.qld.gov.au>; ZERBA Bernadette <Bernadette.Zerba@dnrme.qld.gov.au>
Subject: paradise-dam-review (1).pdf

Hi Adam and Bernadette, a copy of the 2013 report into Paradise Dam is attached.

J

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May 2018	Preliminary Business Case for further improvement works (Stage 2) completed. The study assessed factors including life cycle costs, current and future water demand and environmental factors to determine the best	<p>Completed PBC Stage 2</p> <p><i>(Option considered included the construction of a new dam downstream of the existing dam site, upgrading of existing Paradise Dam</i></p>

	engineering design options to take forward for assessment in the DBC	<i>infrastructure, a reduction in capacity of the existing dam and decommissioning of the dam)</i>
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xxx	State approved BQ to lead PDIP DBC	DBC includes review and planning of two preferred options from the preliminary business case, with targeted completion of DBC late 2020
March- late-August 2019	Further investigations undertaken and completed, including independent technical review, confirming that if an event like the 2013 flood of record occur, the stability of the dam is considered marginal and may fail.	

Paradise Dam Review – Public Works NSW Water Solutions Recommendations

Recommendation	Completed (Date/Time/Process)	Part of DBC
First Term of Reference		
1. There was damage from previous flood events that had not been rectified prior to the January-March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
2. The unrectified damages in the preceding point had no significant effect on the damages which occurred during the January to March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
3. The unrectified damages had no effect on SunWater’s ability to respond to the January to March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
4. SunWater’s documented procedures for dam safety are sound and in accordance with accepted industry practice, with the development permit conditions for the dam, with the regulator’s guidelines (NRM 2002) and otherwise with ANCOLD guidelines, in particular with the guidelines on dam safety management (ANCOLD)	Note only (not a recommendation)	Rectified in works to date
5. It is desirable that the SunWater standards, notably DS13, be amended to better cover the spillways of dams including the energy dissipation zone. SOP 19 would benefit from inclusion of training on case studies of gravity dam failures and their causes and consequences, and on case studies of damages to gravity dam energy dissipators and of rock scour	DS13 was updated at the time and has been updated several times since	
6. It is desirable that SunWater review its procedures for assessing the potential for rock scour at its dams, particularly those dams with high specific power discharges (peak power per metre length of spillway crest). If not already applied, the recognized methodologies for estimating rock scour should become part of the assessment procedure for	Not specific to Paradise Dam and has not been actioned	

<p><i>those dams with high specific power discharges</i></p>		
<p><i>7. It is desirable that the potential for further rock scour at Paradise Dam is estimated carefully before the coming wet season and the work is reviewed by an independent peer reviewer recognized for knowledge of and experience in rock scour estimation methodologies. The peer reviewer should be involved from the outset so as to comment on the analysis scenarios and approach. The outcome of the work should include a “best estimate” result. As a minimum the work should cover a range of flood magnitudes and two configurations:</i></p> <ul style="list-style-type: none"> <i>• The configuration of the rock surface downstream of the dissipator as it will exist on completion of Phase 2 remedial works</i> <i>• The situation where the dissipator apron has been subsequently destroyed and removed by floodwaters.</i> 	<p>Task completed and included in EAP. Some postponed to post wet season during 2014.</p>	
<p><i>8. It is desirable that the stability analysis of critical dam monoliths is refined before the coming wet season and the work is reviewed by two independent peer reviewers, one recognized for knowledge of and experience in gravity dam stability analysis and one a recognized specialist in rock mechanics (unless a suitable person highly skilled in both fields can be found). The peer reviewers should be involved from the outset so as to comment on the analysis scenarios and approach. The outcome of the work should include “best estimate” results as well as results of traditional standards-based analyses. At this stage it appears the analyses should give consideration to:</i></p> <ul style="list-style-type: none"> <i>• The selection of analysis methodology and safety criteria for gravity dam stability</i> <i>• The outcomes of the rock scour analyses under the preceding point</i> <i>• The latest knowledge of foundation geology</i> <i>• A further review of the stabilizing forces provided by tailwater</i> 	<p>Stability revised based on Geotechnically drilling done for Safety review</p>	

<ul style="list-style-type: none"> Any proposed reliance on passive anchors, including the consideration that the load capacity cannot be monitored in the long term. 		
<p>9. It is desirable that the risk assessments be updated when results from the preceding two work items are available. Consideration should be given to these aspects of the risk analyses:</p> <ul style="list-style-type: none"> The results should be “best estimate” In addition to the failure pathway in the interim design report there should be a parallel failure pathway involving destruction of the dissipator apron by abrasion and the energy of the overflow An event tree branch for the probability of sliding, given deep scour to the dam toe, should be included The results from the scour and stability analyses should inform the probability of deep scour and the probability of sliding The reasoning underlying the selection of the risk analysis values needs to be fully documented. 	<p>Sunwater uses event trees as part of the risk assessment process</p>	
<p>10. It is desirable that the results of the updated risk assessment inform SunWater’s level of preparedness for the coming wet season and level of surveillance at the dam in the event of a flood. A precautionary approach should be taken having regard to these facts:</p> <ul style="list-style-type: none"> The analyses have wide uncertainty It is not reasonably practicable to know exactly what is happening in the energy dissipation zone during a flood event Public safety would potentially be at risk. 	<p>Completed using latest risk assessment in December 2013</p>	
<p>11. The reservations of SunWater’s independent peer reviewers regarding the value of analyses before the coming wet season, as proposed in our preceding advices, need to be fully heard and carefully considered.</p>	<p>Completed – risk assessment sent to TRP in October 2013</p>	

<p><i>Resolution of those reservations lies outside the scope of this review</i></p>		
<p>Second Term of Reference</p>		
<p><i>1. SunWater responded adequately prior to, during and immediately after the flood event. A precautionary approach was taken by activating the EAP for a potential sunny day failure event after the flood had subsided and until the emergency repairs had reduced risks to target levels</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>2. The available evidence indicates that SunWater maintained an excellent level of communication with the disaster management groups in the Bundaberg area. SunWater dam safety engineers provided authoritative information on the safety status of the dam and the disaster management groups relied on that information</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>3. Given the circumstances it faced, SunWater commenced the emergency repairs within a reasonable time. The methods for initiating releases, gaining access and determining the damage were reasonable given the time pressures</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>4. The application of risk assessment to assess the damages in a workshop of experienced professional people was a sound approach to the estimation of dam safety risks</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>5. An opportunity for improvement of practices/procedures for any future events exists in the risk assessment process with regard to:</i></p> <ul style="list-style-type: none"> <i>• Documentation of the risk assessment, particularly as regards the description of failure mechanisms and the reasoning which underlies probability values; Assigning “best estimate” risk values. If SunWater sees reasons to take a precautionary approach, that should be done after the “best estimate” risk assessment results are available</i> <i>• Use of event trees primarily, but also fault trees if appropriate, to fully define failure mechanisms;</i> 	<p>Sunwater uses event trees as part of the risk assessment process and have improved the Risk Assessment process significantly since 2013</p>	

<p><i>and Bolstering engineering judgment by science and world experience of dam performance to the maximum practicable extent</i></p>		
<p>6. Given what is now known about the performance of the dam in floods, there would appear to be an opportunity of improving SOP 42, and possibly other guidance documents, with respect to:</p> <ul style="list-style-type: none"> • Ensuring that a dam safety engineer makes a site inspection as a matter of urgency after a report of damage which is potentially a dam safety incident as defined by the regulator • Specifying that “time to notify” under DS 2 of the development permit conditions runs from the date of the engineer’s inspection provided the damage is confirmed as a “dam safety incident” • Specifying who is responsible for initiating notification of the regulator and seeing that it is made within the required time of seven days. 	<p>Completed and amended</p>	
<p>7. There is an opportunity to improve procedures by SunWater training its personnel to enter sufficient words in the “Message” field of Communication Records to enable others to comprehend the subject of the communication</p>	<p>Completed in EEC and Dam Safety Training material at the time</p>	
<p>Third Term of Reference</p>		
<p>1. Given the circumstances it faced, it was not reasonably practicable for SunWater to reduce the time required for completion of the emergency repairs</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>2. The emergency repairs were an appropriate means of progressively reducing risk</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>3. The activation of the EAP for a sunny day failure scenario was a reasonable, though precautionary, means of risk mitigation and it was not reasonably practicable to improve the mitigation measures within the time available without detriment to other critical activities</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>

<p>4. The EAP should be revised to allow for the risks which are now known to exist at Paradise Dam. In particular, response plans should be devised for possible future damage scenarios</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>Fourth Term of Reference</p>		
<p>1. The EAP covers all of the content required by the dam safety regulator's guidelines, though not always as fully as is desirable.</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>2. If the advice under the first Term of Reference is followed, it is desirable that the EAP is revised to take account of the findings of the analyses proposed under that TOR.</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>3. It is desirable that SunWater work together with the disaster management groups in an effort to make the EAP more user friendly and to maximise the effectiveness of evacuation.</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>4. It is desirable that the EAP be revised to better deal with redundant systems for emergency management.</p>	<p>Sunwater has revised its emergency management response since 2013 and has considered the need for redundant systems</p>	
<p>5. It is desirable that the EAP be revised to provide better information on assets and resources which may be required for emergency management</p>	<p>EAP was revised in October 2013 and approved by the Regulator and has been updated annually since, including major revisions to take into account legislation changes and learnings of other events such as Callide Valley in 2015</p>	
<p>6. It is desirable that the EAP be reviewed to remove any content that is not applicable to Paradise Dam</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>7. It is desirable that there be a list of acronyms and their meaning immediately after the table of contents</p>	<p>This was added to the EAP in October 2013 and approved by the Regulator</p>	
<p>8. It is desirable that the EAP be revised to make clear statements about the need for continuous attendance of surveillance personnel at the dam</p>	<p>Implemented in EAP revision in October 2013</p>	
<p>9. It is desirable that the EAP be revised to make clear statements about the urgency for inspections by a dam safety engineer</p>	<p>Flow charts amended and updated</p>	

<p>10. It is desirable that the EAP be revised to give better guidance on the reporting by personnel at the site of changed conditions at the dam</p>	<p>Was amended in Dam Safety courses</p>	
<p>11. It is desirable that consideration be given to revision of the EAP to give guidance on the impact of releases from the dam on downstream access and residents</p>	<p>Completed – downstream residents were added to the EAP for contact</p>	
<p>12. It is desirable that the EAP be revised to provide more useful information on available access modes and routes to the dam</p>	<p>Alternate access routes and travel distances were added to the 2013 EAP amendment</p>	
<p>13. It is desirable that the EAP be revised to provide a more accurate definition of incremental flood effects</p>	<p>EAP updated to reflect failure and non failure flood cases in 2013 amendment</p>	
<p>14. It is desirable that consideration be given to the value of 2D inundation modelling and to the preparation of more accurate mapping on which to plot inundation extent</p>	<p>At the time it was decided to not undertake 2D modelling but this has since been completed</p>	
<p>15. It is desirable that the EAP be revised to remove any inappropriate or outdated references</p>	<p>Completed in EAP update in 2013</p>	
<p>Fifth Term of Reference</p>		
<p>1. It is desirable that the feasibility of improvements at the dam, and to other infrastructure, be investigated as part of the Phase 3 work. These are improvements which may assist dam safety management generally and which may reduce the time required for any future remediation in particular. Some key matters to be examined are:</p> <ul style="list-style-type: none"> • Increasing the flow capacity of culverts on the normal southern access road to the dam to reduce the likelihood of wash-outs • Improvements to the right bank access at the dam that would avoid destruction of the access in every large flood • Improvements that could provide early access to the left bank at the dam for a) inspecting personnel and b) heavy equipment needed for remediation work • Subject to the outcome of the preceding point, provision of safe access down the left bank to the left end of the dissipator apron 	<p>Culverts were installed to facilitate better access to the Dam and the other matters were deferred for inclusion in the Dam Safety review and comprehensive risk assessment as part of the Phase 3 work</p>	

<ul style="list-style-type: none"> • <i>Measures to prevent ingress of gravel or other debris to the environmental flow gate chamber</i> • <i>Measures to safeguard the hydraulic rams that are designed to open the environmental flow gates</i> • <i>Measures to better protect the electric power system used to operate release facilities and to reduce the time required for repair in the event power is lost in floods</i> • <i>Improvements which would allow a greater release discharge without disrupting any potential future remediation work in the energy dissipation.</i> 		
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Date : 24/09/2019 3:32:38 PM

From : "HEARN Robert"

To : "Trevor Dann" , "COWLEY-GRIMMOND Jarrod" , "Bridget Smith" , "John Baxter" , "CHAPMAN Mary" , "NIELSEN Chris"

Subject : Emailing: SHM Paradise Dam Investment Approval Letter, SHM Paradise Dam Investment Approval Brief

Attachment : SHM Paradise Dam Investment Approval Letter.docx;SHM Paradise Dam Investment Approval Brief.docx;

Hi all,

Please find attached the draft SHM investment approval brief for Paradise Dam. Please get back to me with any feedback you have (in track changes) by COB tomorrow.

Thanks

Rob

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SHAREHOLDING MINISTERS FOR
SUNWATER

Our Ref:

s.49 - CTPI
Sunwater Chairman
Sunwater
PO Box 15536
CITY EAST QLD 4002

Dear s.49 - CTPI

Paradise Dam – immediate works to address safety issues

We are writing to you regarding the revised risk assessment for Paradise Dam and the urgent need to mitigate the risk to downstream communities.

The Government supports the need for interim lowering works to commence at the earliest opportunity following the next wet season, and s.49 - CTPI investment approval is given to Sunwater to lower the primary spillway by 5 metres during the 2020 dry season.

s.49 - CTPI

Approval is given to Sunwater to develop a communication engagement strategy, which should include working with Local Disaster Management Groups, local and State government representatives, as well as local State and Federal Members of Parliament. The Government also supports establishment of a community engagement reference group chaired by an independent person with relevant disaster management experience.

Before any public statements are made on this matter, further consultation and approval from the Premier and shareholding Ministers is required due to the sensitive nature of this project and upgrade options, and it is expected that Sunwater will work closely with shareholding departments throughout the process to keep the Government notified of progress and any issues that emerge.

Approval is given to SunWater to release water from Paradise Dam to such a level that existing entitlements are not affected. As the dam is not at risk of failure during dry weather, the community should be notified of water releases well in advance and the released water should be made freely available. All reasonable efforts should be made to make this water usable by customers and the community.

If there is any potential change to the required scope of work, escalation in costs, or material adjustment to the underlying risk assessment then shareholding Ministers and departments should be immediately notified.

We would like to thank Sunwater for consulting early with shareholding Ministers on revised risk assessment for Paradise Dam and appreciate that managing the risk to downstream communities is the priority concern for Sunwater and the Government.

If you have any issues or questions on the advice provided in this letter, please contact **(WHO?)**

Yours sincerely

HON. JACKIE TRAD MP

Deputy Premier, Treasurer
Minister for Aboriginal and Torres Strait Islander Partnerships

Level 39
1 William Street, Brisbane
GPO Box 611, Brisbane
Queensland 4001 Australia
Telephone +617 3719 7100

HON. DR ANTHONY LYNHAM MP

Minister for Natural Resources, Mines and Energy

Level 36
1 William Street, Brisbane
PO Box 15216, Brisbane
Queensland 4001 Australia
Telephone +617 3719 7360

BRIEFING NOTE

FROM	Treasury and Department of Natural Resources, Mines and Energy		
FOR	Deputy Premier, Treasurer Minister for Aboriginal and Torres Strait Islander Partnerships Minister for Natural Resources, Mines and Energy		
SUBJECT	Paradise Dam Emergency Works Investment Approval		
Contact Officer:	Jarrod Cowley-Grimmond, A/Director WSEG	Reference No	CWS CTS
Approval Required	27/09/2019	Reason	To allow the project to commence in March/April 2020
Approved by	AUT	Approved by	DUT

PURPOSE

1. It is recommended that you:

- **Note** that Paradise Dam poses an unacceptable risk to downstream communities.
- **Approve** Sunwater to lower the Paradise Dam primary spillway by up to 5 metres at a cost of up to s.49 - CTPI during the 2020 dry season.
- **Approve** Sunwater to release water from Paradise Dam to a level that does not impact the supply to existing customers.
- s.49 - CTPI
- Sign the letter to s.49 - CTPI Sunwater Chair (Attachment 1).

TIMEFRAMES

s.49 - CTPI

BACKGROUND

5. Dams are long-life assets and require continual assessment, monitoring and maintenance. In Queensland, dam owners must meet the dam safety regulations and guidelines under the *Water Supply (Safety and Reliability) Act 2008*.

6. Paradise Dam was built by Burnett Water Pty Ltd in 2005 and was transferred to Sunwater following the completion of construction. It is a key component of the Bundaberg Water Supply Scheme and holds up 300,000 megalitres, of which 20,000 is supplied to irrigation customers and 10,000 to the city of Bundaberg.
7. Following the rectification of scouring damage that occurred during the 2013 flood, further dam safety investigations were undertaken and identified the need for further upgrades to strengthen the primary spillway. Building Queensland is leading the development of a Detailed Business Case investigating upgrade options.
8. Recent core samples of Roller Compacted Concrete (RCC) at Paradise Dam have revealed that the quality of the RCC is significantly worse than originally expected and this has significantly increased the dam safety risk.

~~8-9.~~ There is a risk that during a severe flood, similar to the one that occurred in 2013, the external loads on the dam could overcome the shear strength (resistance to sliding) of the primary spillway. This could result in a sudden sliding failure in one or more monoliths. If multiple monoliths failed simultaneously, or in rapid succession, the resulting flood wave would be steep and fast moving and could cause downstream water levels to rise by meters in a 15 minute period and with high velocity flow rates.

~~9-8.~~ The conclusion of the RCC investigation, which was endorsed by a Technical Review Panel (TRP) in early September 2019, indicated that the main spillway could fail in a 0.5% annual exceedance probability flood event (1 in 200 year event), meaning there is 0.5% probability the dam could fail during the next wet season.

~~10-9.~~ There are 48,000 persons at risk downstream of Paradise Dam who would need to be evacuated in a dam safety emergency. Most people would need to be evacuated from the Bundaberg area, and many in or around already flood impacted areas, within a 24 to 48 hour period.

~~10.~~ Other dam incidents indicate that an evacuation of this scale would be challenging, and it is estimated that the failure of Paradise Dam during a flood event with a 0.5% *annual exceedance probability* would incrementally increase the total death toll from 8 to 18.

~~11.~~

~~6-11.~~ The current Emergency Action Plan (EAP) was revised earlier this year to address the elevated dam safety risk. Under the revised EAP, an alert to prepare for evacuation of major population centres, including Bundaberg, will be triggered when flood levels reach 3 metres below those experienced during the 2013 flood event (73.38 mAHD, which is around 6m over the spillway).

ISSUES

12. Paradise Dam poses an unacceptable risk to downstream communities and interim upgrade options are urgently required to mitigate this risk.
13. Sunwater as the dam owner has a legal obligation to lower the risk "*as soon as is reasonably practicable*", and "*as low as is reasonably practicable*".

14. s.73 - Irrelevant Information

15.

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16. The estimated cost of lowering the primary spillway by 5 metres is between s.49 - CTPI and therefore shareholding Minister investment approval is required for Sunwater to proceed.

17. Sunwater should established a project steering committee for the 5 metre lowering project to provide project oversight and consult closely with shareholding departments on project planning and delivery activities.

18. Shareholding Ministers should be immediately notified of any possible deviation from the approved scope of work, escalation in cost or updates to the underlying risk assessment.

19. s.49 - CTPI

20.

21.

22. The 5 metres lowering option was approved on the basis that it balances the need to urgently mitigate the dam safety risks while not committing to an upgrade option that would permanently reduce storage capacity. Another benefit is that it provides further time to consider second stage upgrade options to be delivered in 20221 while not precluding the possibility of upgrading the dam to its full supply level.

23. Lowering the dam by 5 metres will reduce the likelihood of a dam failure from a 1 in 200 *annual exceedance probability* event to a 1 in 3,000 *annual exceedance probability* event. This means the risk of Paradise Dam failing during the 2020–21 wet season will be reduced from a 0.5 per cent probability of occurring to a 0.003 per cent probability of occurring.

24. The 5 metre lowering option will partially mitigate the dam safety risk, however Paradise Dam will still be well above the legislated limit of tolerability, which is the minimum safety standard all referable dams must meet. This is why further upgrade options will still need to be developed.

Release water from Paradise Dam

7-25. s.73 - Irrelevant Information

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8-26. Only 20 per cent of allocations have been sold to date so a significant volume of the total storage capacity could be released (approximately 200,000 ml???) without impacting customers.

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9-27. Temporarily reducing the full supply level of Paradise Dam will not materially decrease the risk of dam failure, because during the 2013 flood the dam refilled many times over, however

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it may provide additional warning time to prepare downstream communities to evacuate during a flood emergency.

40-28. Sunwater should notify customers and downstream communities of water releases well in advance and the released water should be made freely available. All reasonable efforts should be made to make the released water usable by customers and downstream communities.

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Consultation

29. The Government decision to lower Paradise Dam by 5 metres during the 2020 dry season was announced on 24 September 2019, however there has been no other community consultation or communications on the escalated dam safety risk.

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~~44.~~

42-30. Sunwater should immediately commence planning a community engagement strategy and the establishment of a community engagement reference group chaired by an independent person with relevant disaster management experience. The strategy should include plans for engagement with the Local Disaster Management Group, local and State Government representatives, and State and Federal parliamentary members.

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43-31. Sunwater should consult with DNRME and Queensland Treasury when developing its community engagement strategy and seek further Premier and shareholding Minister approval before community engagement commences.

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FINANCIAL IMPLICATIONS

44-32. s.49 - CTPI

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45-33. There is limited prospect of recovering these costs from customers downstream of the dam because the majority of the allocations in the dam have not been sold and customers would be strongly opposed to meeting dam improvement costs, which may not benefit them directly, and which are the result of possible construction defects.

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16. s.49 - CTPI

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RESULTS OF CONSULTATION

24-39. The Department of Premier and Cabinet has been briefed on the most recent developments with respect to Paradise Dam. The Under Treasurer and other officers of

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Queensland Treasury have been briefed by Sunwater. There will need to be close collaboration with DES, DAF, QFES on the necessary approvals to ensure construction can commence in March 2020.

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RECOMMENDATION

22-40. That you:

- **Note** the information contained in this brief on the Dam Safety Risks at Paradise Dam.

a. **(1) Approve** Sunwater to lower the Paradise Dam primary spillway by 5 metres during 2020 dry season at a cost of up to s.49 - CTPI

b. **(2) Note** that Sunwater is required to complete an options analysis of further upgrade to be delivered in 2021 by the end of February 2020.

c. **(3) Approve** Sunwater to release water from Paradise Dam and reduce the supply level to the extent that existing customers are not impacted

d. **(4) Sign** the letter to s.49 - CTPI Sunwater Chair, advising her accordingly (**Attachment 1**).

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Frankie Carroll
 Under Treasurer

James Purtil
 Director-General
 Department of Natural Resources, Mines and Energy

/ /

/ /

<input type="checkbox"/> Approved	<input type="checkbox"/> Not approved	<input type="checkbox"/> Noted
Comments		
_____ HON. JACKIE TRAD MP Deputy Premier, Treasurer Minister for Aboriginal and Torres Strait Islander Partnerships		
/ /		

<input type="checkbox"/> Approved	<input type="checkbox"/> Not approved	<input type="checkbox"/> Noted
Comments		
_____ HON. ANTHONY LYNHAM MP Minister for Natural Resources, Mines and Energy		
/ /		

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Date : 23/09/2019 2:57:10 PM
From : "COWLEY-GRIMMOND Jarrod"
To : "DOBE Linda" , "ZERBA Bernadette"
Subject : FW: 190922_History of Paradise Dam
Attachment : 190922_History of Paradise Dam.docx;image793695.png;image619116.png;image383156.png;image966529.png;image895520.jpg;image334722.jpg;

From: s.49 - CTPI
Sent: Monday, 23 September 2019 2:43 PM
To: COWLEY-GRIMMOND Jarrod
Subject: FW: 190922_History of Paradise Dam

Am tidying up and adding report and our response but this addresses most of recommended items in report with works undertaken

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North, Level 9,
515 St Pauls Terrace, Fortitude
Valley, Queensland 4006

sunwater.com.au



From: s.49 - CTPI
Sent: Monday, 23 September 2019 2:37 PM
To: s.49 - CTPI
Cc: s.49 - CTPI
Subject: 190922_History of Paradise Dam

s.49 - C

Can you pls tidy up the table and font etc and send back to s.49 - CTPI

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North, Level 9,
515 St Pauls Terrace, Fortitude
Valley, Queensland 4006

sunwater.com.au



History of Paradise Dam

Date	Issue	Action/Overview
November 2005	Paradise Dam construction complete at cost of [s.49 - CTPI]	
16 December 2005	Burnett Water Pty Ltd became a subsidiary company of Sunwater. Paradise Dam now owned and operated by Sunwater.	
March 2010	Paradise Dam filled for the first time	
December 2010 – April 2011	<p>Paradise Dam inundated by extreme weather and three major flood events:</p> <ul style="list-style-type: none"> • December 2010 – peak above crest 5.96 metres (2nd) – first spill event • January 2011 – peak above crest 4.23 metres (3rd) • March 2011 – peak above crest 3.87 metres (4th) <p>Only minor structural damage.</p>	No Action Required
January 2013	<p>Paradise Dam damaged by Tropical Cyclone Oswald – extensive scour downstream of the primary spillway compounding damage from a prior 2011 flood event:</p> <ul style="list-style-type: none"> • Flood of record – peak above crest 8.65 metres (1st) • At the peak of the flood approximately 1,425,600 ML (4.6 times the dam's capacity) was assessed as flowing over the spillway each day 	<p>March 2013: Urgent repair work undertaken at cost of [s.49 - CTPI] (including Phase 1 involved undertaking emergency repairs to enable the dissipator to withstand a late 2013 season flood event. These works were completed in June 2013. [s.49 - CTPI] and Phase 2 to mitigate any immediate path to failure. [s.49 - CTPI] and included downstream scour holes, dissipator sill and rock foundations.</p> <p>December 2013: Further urgent repair work undertaken at a cost of [s.49 - CTPI] million (effectively CRA Phase 4A to dissipator slab to provide immunity for a flood loading equivalent to that experienced in the January 2013 flood) from the DSR being undertaken.</p> <p>Total Cost: [s.49 - CTPI]</p>

Date	Issue	Action/Overview
March 2013 to Oct 2014	SunWater brought forward the comprehensive dam safety review of Paradise Dam, originally scheduled for 2025, This Report confirmed that the dam is safe under normal operating conditions and can safely pass a flood of similar magnitude to the 2013 event, which is the largest flood on record.	The Paradise Dam Full Dam Safety Review submitted to Regulator on 21 Oct '14 - effectively Phase 3 of CRA The CRA also assessed a range of options and costs to mitigate potential dam safety risks.
October 2014 to February 2015	Updated Interim Comprehensive Risk Assessment (CRA) completed and submitted to the Regulator The CRA placed the dam above the Australian National Committee on Large Dams (ANCOLD) Guideline Limit of Tolerability for failure – due to the risk of downstream scouring undermining the integrity of the spillway structure.	CRA involved two stages for DIP with works and business case submitted in April 2015 to the Regulator and approved by the Sunwater Board
February 2015	Paradise Dam inundated by extreme weather and spilled: <ul style="list-style-type: none"> February 2015 – peak above crest 2.58 metres (5th) 	
May 2015	SunWater commenced detailed planning and design to undertake Stage 2 works that will strengthen the toe of two sections of the primary spillway.	
June 2015	Other minor ancillary repairs of CRA Phase 2 works (such as handrails, electrical works etc).	Completed
June 2016	CRA involved Stage 1 DIP planning for works to be undertaken which commenced in April 2016 and completed in 2017 to strengthen monoliths D&K and completed an additional section of concrete protection to the base of the primary spillway involving installation of anchor bars and reinforcement of concrete	August 2017: Completed Stage 1 improvement works at a total cost of s.49 - CT million
2015 to December 2016	Improved EAP requirements as part of studies and CRA including emergency response planning in liaison with local and district disaster management groups	Completed

Date	Issue	Action/Overview
May 2018	Preliminary Business Case for further improvement works (Stage 2) completed. The study assessed factors including life cycle costs, current and future water demand and environmental factors to determine the best engineering design options to take forward for assessment in the DBC	Completed PBC Stage 2 <i>(Option considered included the construction of a new dam downstream of the existing dam site, upgrading of existing Paradise Dam infrastructure, a reduction in capacity of the existing dam and decommissioning of the dam)</i>
October 2018	Expression of Interest (EOI) process for water allocation from Paradise Dam tested demand and increased water sold to 20 per cent (additional 12,000ML)	Input into DBC demand study
2018	Sunwater commenced preparatory works and studies for the Paradise Dam Spillway DIP Stage 2 and made recommendation to State for the DBC to include analysis of full upgrade of the existing dam and a potential reduction in capacity of the existing dam by lowering the spillway Early indicative costs s.49 - CTPI	
October 2018 – February 2019	To develop the design basis for the options being considered in the Detailed Business Case, GHD reviewed the stability and shear strength of the dam and spillway.	
Late February 2019	Initial findings indicated a second major risk (in addition to the risk of downstream scouring identified in the 2016 CRA and DSR) regarding the shear strength and stability of the concrete that was used to construct the dam and spillway, which may lead to a failure.	
xxx	State approved BQ to lead PDIP DBC	DBC includes review and planning of two preferred options from the preliminary business case, with targeted completion of DBC late 2020.
March – late-August 2019	Further investigations undertaken and completed, including independent technical review, confirming that if an	

Date	Issue	Action/Overview
	event like the 2013 flood of record occur, the stability of the dam is considered marginal and may fail.	

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RTI Act 2009

Date : 6/09/2019 2:23:37 PM
From : "COWLEY-GRIMMOND Jarrod"
To : "DOBE Linda"
Cc : "VENABLES Celia"
Subject : FW: Draft Paradise DAM Briefing Note
Attachment : PRODUCTION-#2472491-v3-20190903 - SHM brief for noting -
_Update_on_Paradise_Dam_Revised_Risk_Assessment.docx;image296881.png;image923402.png;image610979.png;image016820.png;image480639.jpg;

Hi Linda,

We received this briefing from Sunwater on Thursday and my plan was to send it up to the DLO today after we had briefed Simon. Given that we wont have a verbal briefing do you want me to send this to the DLO now. Sunwater want to ensure that the Minister's Office has received it, but don't want to send it to the Min corro box to minimise the number of people who have seen this. We are preparing a covering brief with some advice which we will have up to the Minister next week, once we have co-ordinated with Treasury.

My view is that the sooner we can get this to the MO the better, but noting that there is no immediate problem, as no weather events are likely in the coming week.

Shall I just send this up to the DLO now?

Thanks

Jarrold

From: s.49 - CTPI
Sent: Thursday, 5 September 2019 10:16 AM
To: COWLEY-GRIMMOND Jarrod
Subject: Draft Paradise DAM Briefing Note

Jarrold

Further to our chat earlier yesterday and your conversation with s.49 last night I attach the draft Briefing Note.

Any questions please give me a call.

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North, Level 9,
515 St Pauls Terrace, Fortitude
Valley, Queensland 4006

sunwater.com.au



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SHAREHOLDING MINISTERS BRIEF FOR NOTING

FROM: s.49 - CTPI

DATE: 5 September 2019

SUBJECT: Update regarding Paradise Dam Revised Risk Assessment

Recommendation

That the Shareholding Ministers and departmental representatives **NOTE:**

- the revised dam stability assessment for Paradise Dam has been completed and should an event similar event to the 2013 flood of record occur, the stability of the dam is considered marginal and may fail, resulting in potential loss of life and property. The Paradise Dam Emergency Action Plan (EAP) would respond to this scenario by triggering the evacuation of significant numbers of Bundaberg and downstream residents
- Sunwater’s preliminary recommendation is to proceed with an accelerated delivery of early stage (emergency) risk reduction works, comprising initial lowering of the spillway by a minimum of 5 metres with a strong preference to lower the spillway by 10 metres to achieve improved early risk reduction outcomes (note however a 10-metre lowering will preclude the Detailed Business Case (DBC) option for full upgrade works to maintain the current full supply level)
- that emergency risk reduction works are required in advance of the full Dam Improvement Project (DIP), as further works will be required (second stage) to achieve an acceptable risk reduction, given the dam is the highest rated risk and significantly above the limit of tolerability
- indicative preliminary cost estimates for emergency risk reduction works are in the order of s.49 - CTPI s.49 - CTPI and Sunwater’s recommendation is to proceed with this scope outside of the Building Queensland Business Case Framework, though Building Queensland will continue to lead and expedite the DBC for the full DIP (required for the second stage)
- the emergency risk reduction work options need to be workshopped on an urgent basis with all relevant Government stakeholders to review the evaluation of early risk reduction measures and agree on the process and scope for any early stage works (extent of lowering), including potential approval exemptions, to facilitate these works and the scope of the DBC.

Paradise Dam Safety Risk

- As advised on 1 March 2019 (refer to Sunwater briefing note #2414975), Sunwater’s design consultant reviewed the dam stability for Paradise Dam and assessed a potential significant increased risk of dam failure, though pending further investigations and review
- Further review has now been completed (including onsite geotechnical investigations, revised assessment by Sunwater’s consultant, engagement of a Technical Review Panel (with 6 national and international experts), and findings from the expert review workshop on 27 and 28 August 2019
- The review has confirmed Paradise Dam’s revised risk profile and that, should a similar event to that of the 2013 flood of record occur, the dam is at, or close to, marginal stability and may fail

SUNWATER

Briefing Officer: s.49 - CTPI
 Telephone:
 File Ref: Doc# 2472491

Approved: s.49 - CTPI
 Date: 5 September 2019

CONSULTATION

DNRME: _____
 Treasury: _____
 Date: _____

- Sunwater’s EAP will trigger the evacuation of significant numbers of Bundaberg and downstream residents if flood levels approach, or are forecast to reach, the 2013 peak flood level. The current EAP will generate an Emergency Alert message (sent by State Disaster Groups at Kedron in conjunction with the LDMG or Council). This has been in place since March 2019. To predict flood levels in advance, Sunwater maintains a flood forecasting model that will identify flood levels based on rainfall accumulations throughout the Burnett catchment. In addition, early advice is issued to residents in the immediate downstream reaches of the river

Sunwater’s Response to Paradise Dam Safety Risk

- In direct response to the confirmed Paradise Dam safety risk, Sunwater is:
 - undertaking additional specific flood hazard impact mapping and engagement with the Bureau flood warning service to review evacuation triggers and other actions currently being planned
 - reviewing emergency procedures for Paradise Dam with Bundaberg Regional Council and the Local Disaster Management Group (LDMG) prior to the 2019/2020 wet season – noting that initial briefings were carried out in March 2019
 - preparing an engagement campaign in conjunction with Bundaberg Regional Council once the initial scope and timing of mitigation works is agreed. This is to ensure we advise publicly of the issue and the actions being undertaken concurrently. Bundaberg Regional Council (BRC) has a publicly available flood mapping tool that we would aim to utilise and leverage from previous engagement conducted by BRC on community flood preparations
 - assessing options to identify ways to reduce dam safety risks in line with good practice, community expectations, and legal and dam safety obligations, including:
 - a) Fast-tracking early stage emergency works to lower the spillway crest level by 10 metres, followed by further improvement works as required (including anchoring and dam strengthening works, as per the current DBC for the full Paradise Dam Improvement project scope) – though this option will render returning the spillway level to its current full supply volume impractical (one of the options considered in the Business Case)
 - b) Fast-tracking early stage emergency works to partially lower the spillway crest level by 5 metres, followed by further improvement works as required – this would allow both Detailed Business Case options to be considered
 - c) Accelerating the current DBC process and full project delivery as a single stage (though constrained by current project processes and approvals)
 - reviewing project approval requirements, emergency powers, and possible exemptions to facilitate early stage or accelerated work, for discussion with the Department of Natural Resources, Mines and Energy (DNRME)
 - updating the Paradise Dam Stakeholder Management Plan and developing a Communication Action Plan to outline how key stakeholders (eg. community, customers, local agencies, LDMG) will be informed and engaged regarding the dam’s risk profile and any early stage risk reduction measures.
- In order to achieve risk reduction benefits as soon as reasonably practical (in accordance with Sunwater’s Dam Safety Policy) and to discharge our legal duty of care, the early stage works in scenarios a) and b) above are recommended to proceed outside of the Building Queensland Business Case Framework (the estimated cost for these works are of the order of s.49 - CTPI), and seeking exemptions and/or expedited project approvals as applicable

- Project approvals that may apply for early stage works include:
 - Development Application for a referable dam (impact assessable) (*Planning Act 2016*, and *Water Supply (Safety and Reliability) Act 2008*),
 - Waterway Barrier Works (*Fisheries Act 1994*),
 - Clearing of protected plans (*Nature Conservation Act 1992*) for left bank access,
 - Species Management Program for impacting animal breeding places including turtles, platypus, lungfish (*Nature Conservation Act 1992*) for water releases,
 - Interim Program approval (*Water Act 2000*) to lower storage level, and
 - possible impact on Matters of National Environmental Significance (*Environment Protection and Biodiversity Conservation Act 1999*)
- If project approvals are to be expedited, design and procurement activities can proceed through late 2019 to potentially enable award and commencement of access works early 2020 (ramp and bridge works from abutments to spillway crest), though these works will be impacted and limited by wet weather. Construction works to follow to lower the spillway (strengthen training walls, lowering of the intake tower, demolition of spillway crest, lowering the spillway, and capping the lowered crest) to an interim extent and level in the dry season by late 2020, and completion by late 2021
- The remaining improvement works (second stage) are proposed to be undertaken as per current DBC processes and full project approvals, for completion by end 2025
- Note that early stage emergency works (spillway lowering) will not achieve full compliance for acceptable risk reduction (being below the Australian National Committee on Large Dams (ANCOLD) limit of tolerability and considering Guideline principles for As Low as Reasonably Practical), though will achieve significant risk reduction benefits as an interim measure
- It is further noted that current assessment for the full upgrade option (Option 2 from Preliminary Business case, refer to Background below) is that it may not be practical to implement sufficient improvement scope to achieve an acceptable risk reduction outcome. It is therefore likely that some permanent lowering of the spillway level may be required as a minimum (less than 10 metres)
- In addition to options above, temporary operational lowering of the full supply level of the dam has also been assessed, though this indicated it would provide negligible risk reduction benefits on its own due to the size of Paradise Dam and the volume of water during an event the size of the 2013 flood (though this may still be implemented)
- The outcomes of any decision to implement early stage risk reduction measures will impact on the full Paradise Dam Improvement Project scope which is currently subject to a Building Queensland-led Detailed Business Case – Sunwater has advised Building Queensland, and will work with them to determine how best to progress
- Sunwater is seeking to confirm early stage risk reduction measures by late September 2019, following a proposed options workshop with DNRME and Treasury.

Detailed Business Case

- s.49 - CTPI

- s.49 - CTPI
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Date : 9/09/2019 1:19:02 PM
From : "COWLEY-GRIMMOND Jarrod"
To : "'adrian.jeffreys@premiers.qld.gov.au'"
Cc : "DOBE Linda"
Subject : FW: Draft Paradise DAM Briefing Note
Attachment : PRODUCTION-#2472491-v3-20190903 - SHM brief for noting -
_Update_on_Paradise_Dam_Revised_Risk_Assessment.docx;image296881.png;image923402.png;image610979.png;image016820.png;image480639.jpg;

Hi Adrian,

Linda asked me to send you a copy of Sunwater's draft BN re Paradise Dam.

Thanks

Jarrod

From: s.49 - CTPI
Sent: Thursday, 5 September 2019 10:16 AM
To: COWLEY-GRIMMOND Jarrod
Subject: Draft Paradise DAM Briefing Note

Jarrod

Further to our chat earlier yesterday and your conversation with Nicole last night I attach the draft Briefing Note.

Any questions please give me a call.

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North, Level 9,
515 St Pauls Terrace, Fortitude
Valley, Queensland 4006

sunwater.com.au



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SHAREHOLDING MINISTERS BRIEF FOR NOTING

FROM: s.49 - CTPI

DATE: 5 September 2019

SUBJECT: Update regarding Paradise Dam Revised Risk Assessment

Recommendation

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SUNWATER

Briefing Officer: s.49 - CTPI
 Telephone:
 File Ref: Doc# 2472491

CONSULTATION

Approved: s.49 - CTPI
 Date: 5 September 2019
 DNRME: _____
 Treasury: _____
 Date: _____

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 - Waterway Barrier Works (*Fisheries Act 1994*),
 - Clearing of protected plans (*Nature Conservation Act 1992*) for left bank access,
 - Species Management Program for impacting animal breeding places including turtles, platypus, lungfish (*Nature Conservation Act 1992*) for water releases,
 - Interim Program approval (*Water Act 2000*) to lower storage level, and
 - possible impact on Matters of National Environmental Significance (*Environment Protection and Biodiversity Conservation Act 1999*)
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- Sunwater is seeking to confirm early stage risk reduction measures by late September 2019, following a proposed options workshop with DNRME and Treasury.

Detailed Business Case

- s.49 - CTPI

s.49 - CTPI

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Published on DNRME Disclosure Log
RTI Act 2009

Date : 23/09/2019 3:26:04 PM
From : "COWLEY-GRIMMOND Jarrod"
To : "'Adam Obeid"' , "Zanatta Simon"
Cc : "DOBE Linda" , "ZERBA Bernadette"
Subject : FW: Paradise Dam
Attachment : PRODUCTION-#1444282-v2-0130828_Letter_to_Dam_Safety_Regulator_(DRS)_re_Paradise_Dam_independent_review_(final).DOCX;190922_History of Paradise Dam Formatted.docx;Paradise Dam Review - Public Works NSW Water Solutions.docx;image633968.png;image419531.png;image967859.png;image164396.png;image156065.jpg;image001.png;image002.jpg;

Hi Adam and Simon,

Further to Sunwater's email I can advise that EAPs (including Paradise Dam's) in Queensland have been substantially updated since 2013 and are regularly reviewed.

The report did not investigate the stability of the Roller Compacted Concrete (RCC), and made no findings or recommendations in that regard. The report focussed on the damage to the concrete aprons and stilling basins and the abrasion of the dissipator slab, as well as the EAP and Sunwater's response to the flood event.

Sunwater has also completed the following works on the Dam:

- Phase 1 – March 2013 Emergency Repairs to the dissipator
- Phase 2 – December 2013 – Downstream Work to scour holes, dissipator sills and rock
- Phase 3 – October 2014 – submission of Comprehensive Safety Review to Regulator

In addition to that work Sunwater has also strengthened the monoliths and completed additional protection work at the base of the spillway (this is the first stage of the Dam Improvement Program)

Kind regards

Jarrod



Jarrod Cowley-Grimmond
Director – Economics and Governance
Water Supply Business Unit
Natural Resources Division
Department of Natural Resources, Mines and Energy

P: 0733305061 M: [s.49 - CTPI]
E: jarrod.cowley-grimmond@dnrme.qld.gov.au
A: level 8 1 William Street, Brisbane QLD 4001
W: www.dnrme.qld.gov.au



From: [s.49 - CTPI]
Sent: Monday, 23 September 2019 3:00 PM
To: Zanatta Simon; DOBE Linda; COWLEY-GRIMMOND Jarrod; Jan Martin @ Ministerial
Cc: [s.49 - CTPI]
Subject: Paradise Dam
Importance: High

All

Attached is:

1. History of Paradise Dam key points which include Public Works NSW report (effectively EAPs updated, flood repairs undertaken, CRA completed reflecting Stage 1 DIP works required and have been completed and Stage 2 DIP currently under DBC
2. SunWater's response a week after on the Public Works NSW report
3. Status of what has been completed in relation to the Public Works NSW report (one item outstanding)

Kind regards

[s.49 - CTP]

s.49 - CTPI

sunwater

s.49 - CTPI

Green Square North, Level 9,
515 St Pauls Terrace, Fortitude
Valley, Queensland 4006

sunwater.com.au



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RTI Act 2009

Our ref: 13-000420/001 #1444282
Contact Name: s.49 - CTI
Telephone: 3120 0065

29 August 2013

Mr Peter Allen
Director Dam Safety
Department of Energy and Water Supply
PO Box 15456
CITY EAST QLD 4002

Dear Peter

PARADISE DAM –REPORT FOR THE REVIEW OF DAM SAFETY MANAGEMENT ACTIONS (the Report)

I refer to the email of s.49 - CTPI dated 22 August 2013 and the request to SunWater to provide comment on the Report from external reviewers s.49 - CTPI

SunWater notes that the Report, similar to the draft report portrays SunWater's response and management of the flood event and subsequent damage to Paradise Dam (**the Dam**) favourably. The reviewer notes that SunWater's dam safety management system is world class. Nonetheless, SunWater welcomes the opportunity to receive constructive feedback such that we may continue to improve our approach. We provide our formal response as follows:

1. FACTUAL MATTER

On pages 8-1, the Report notes "*The lapse of time from report of damage to energy dissipator on 8 February to engineer inspection on 21 February 2013. According to the letter of the CEO of SunWater of 12 August 2013 engineers did attend the site during this period.....The point is though that, in terms of the time of seven days specified for reporting of incidents to the dam safety regulator as set out in DS 2 of the development permit conditions, the time has apparently run from 21 February 2013..*" This statement presupposes that an incident, as defined by the *Queensland Dam Safety Management Guidelines – February 2002*, was known to have occurred.

SunWater holds a different view on this matter. SunWater would be pleased to provide you with additional information if you consider it a matter to investigate further.

2. ADVICE CONTAINED IN THE REPORT

I note that section 11 of the Report headed "Advice" makes a number of recommendations aimed at improving knowledge such that risk mitigation measures in the Emergency Action Plan (**EAP**) can be updated.

SunWater is currently revising the EAP to meet the requirements of the *Water (Safety and Reliability) Act*. A revised EAP will be submitted to you for approval by the 1 October 2013 deadline. SunWater expects to submit further updates of the EAP following the implementation of advice contained in the Report.

SunWater is currently assessing the resourcing needs necessary to implement the advice in the report. Implementation will be scheduled in the context of available resources. SunWater would welcome the opportunity to meet with you to discuss the implementation timetable.

3. OTHER MATTERS

I note from some of the media coverage associated with this review that there may be an expectation in sectors of the community that the Report will deal with a range of other matters outside the terms of reference of the review (e.g. the cause of the damage, cost of repairs and the reasons why a relatively new dam experienced such damage). As previously advised by SunWater, Phase 3 investigations will include a safety review in accordance with the *Queensland Dam Safety Management Guidelines – February 2002* which will include an assessment of the dam against current standards. SunWater suggests that this comprehensive safety review will potentially provide important data, information and insights that may be relevant to the consideration of these other matters. SunWater therefore seeks deferring any decision to extend the independent review until the outcomes of the safety review are known and able to be properly considered.

s.49 - CTPI asked whether SunWater sought to have any parts of the Report redacted in the event that the Report is published. SunWater does not require any part of the Report to be redacted other than personal information such as names or anything that can identify a person (such as photos of SunWater employees).

If you wish to discuss these matters further please do not hesitate to call s.49 - CTPI

s.49 - CTPI

Yours sincerely

s.49 - CTPI

History of Paradise Dam

Date	Issue	Action/Overview
November 2005	Paradise Dam construction complete at cost of s.49 - CTPI	
16 December 2005	Burnett Water Pty Ltd became a subsidiary company of Sunwater. Paradise Dam now owned and operated by Sunwater.	
March 2010	Paradise Dam filled for the first time	
December 2010 – April 2011	<p>Paradise Dam inundated by extreme weather and three major flood events:</p> <ul style="list-style-type: none"> December 2010 – peak above crest 5.96 metres (2nd) – first spill event January 2011 – peak above crest 4.23 metres (3rd) March 2011 – peak above crest 3.87 metres (4th) <p>Only minor structural damage.</p>	No Action Required
January 2013	<p>Paradise Dam damaged by Tropical Cyclone Oswald – extensive scour downstream of the primary spillway compounding damage from a prior 2011 flood event:</p> <ul style="list-style-type: none"> Flood of record – peak above crest 8.65 metres (1st) At the peak of the flood approximately 1,425,600 ML (4.6 times the dam’s capacity) was assessed as flowing over the spillway each day 	<p>March 2013: Urgent repair work undertaken at cost of s.49 - CTPI (including Phase 1 involved undertaking emergency repairs to enable the dissipator to withstand a late 2013 season flood event. These works were completed in June 2013. s.49 - CTPI and Phase 2 to mitigate any immediate path to failure. s.49 - C and included downstream scour holes, dissipator sill and rock foundations.</p> <p>December 2013: Further urgent repair work undertaken at a cost of s.49 - CTPI (effectively CRA Phase 4A to dissipator slab to provide immunity for a flood loading equivalent to that experienced in the January 2013 flood) from the DSR being undertaken.</p> <p>Total Cost: s.49 - CTPI</p>
March 2013 to Oct 2014	SunWater brought forward the comprehensive dam safety review of Paradise Dam, originally scheduled for 2025, This Report confirmed that the dam is safe under normal operating conditions and	The Paradise Dam Full Dam Safety Review submitted to Regulator on 21 Oct '14 - effectively Phase 3 of CRA The CRA also assessed a range of options

	can safely pass a flood of similar magnitude to the 2013 event, which is the largest flood on record.	and costs to mitigate potential dam safety risks.
22 August 2013	Paradise Dam Review – Public Works NSW Water Solutions	Paradise Dam – Report for the Review of Dam Safety Management Actions (the Report) – 29 August 2013
October 2014 to February 2015	<p>Updated Interim Comprehensive Risk Assessment (CRA) completed and submitted to the Regulator</p> <p>The CRA placed the dam above the Australian National Committee on Large Dams (ANCOLD) Guideline Limit of Tolerability for failure – due to the risk of downstream scouring undermining the integrity of the spillway structure.</p>	CRA involved two stages for DIP with works and business case submitted in April 2015 to the Regulator and approved by the Sunwater Board
February 2015	<p>Paradise Dam inundated by extreme weather and spilled:</p> <ul style="list-style-type: none"> February 2015 – peak above crest 2.58 metres (5th) 	
May 2015	SunWater commenced detailed planning and design to undertake Stage 2 works that will strengthen the toe of two sections of the primary spillway.	
June 2015	Other minor ancillary repairs of CRA Phase 2 works (such as handrails, electrical works etc).	Completed
June 2016	CRA involved Stage 1 DIP planning for works to be undertaken which commenced in April 2016 and completed in 2017 to strengthen monoliths D&K and completed an additional section of concrete protection to the base of the primary spillway involving installation of anchor bars and reinforcement of concrete	August 2017: Completed Stage 1 improvement works at a total cost of s.49 - CTPI
2015 to December 2016	Improved EAP requirements as part of studies and CRA including emergency response planning in liaison with local and district disaster management groups	Completed
May 2018	Preliminary Business Case for further improvement works (Stage 2) completed. The study assessed factors including life cycle costs, current and future water demand and environmental factors to determine the best	<p>Completed PBC Stage 2</p> <p><i>(Option considered included the construction of a new dam downstream of the existing dam site, upgrading of existing Paradise Dam</i></p>

	engineering design options to take forward for assessment in the DBC	<i>infrastructure, a reduction in capacity of the existing dam and decommissioning of the dam)</i>
October 2018	Expression of Interest (EOI) process for water allocation from Paradise Dam tested demand and increased water sold to 20 per cent (additional 12,000ML)	Input into DBC demand study
2018	Sunwater commenced preparatory works and studies for the Paradise Dam Spillway DIP Stage 2 and made recommendation to State for the DBC to include analysis of full upgrade of the existing dam and a potential reduction in capacity of the existing dam by <u>lowering the spillway</u> . Early indicative costs s.49 - CTPI	
October 2018 – February 2019	To develop the design basis for the options being considered in the Detailed Business Case, GHD reviewed the stability and shear strength of the dam and spillway.	
Late February 2019	Initial findings indicated a second major risk (in addition to the risk of downstream scouring identified in the 2016 CRA and DSR) regarding the shear strength and stability of the concrete that was used to construct the dam and spillway, which may lead to a failure.	
xxx	State approved BQ to lead PDIP DBC	DBC includes review and planning of two preferred options from the preliminary business case, with targeted completion of DBC late 2020
March- late-August 2019	Further investigations undertaken and completed, including independent technical review, confirming that if an event like the 2013 flood of record occur, the stability of the dam is considered marginal and may fail.	

Paradise Dam Review – Public Works NSW Water Solutions Recommendations

Recommendation	Completed (Date/Time/Process)	Part of DBC
First Term of Reference		
1. There was damage from previous flood events that had not been rectified prior to the January-March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
2. The unrectified damages in the preceding point had no significant effect on the damages which occurred during the January to March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
3. The unrectified damages had no effect on SunWater’s ability to respond to the January to March 2013 flood event	Note only (not a recommendation)	Rectified in works to date
4. SunWater’s documented procedures for dam safety are sound and in accordance with accepted industry practice, with the development permit conditions for the dam, with the regulator’s guidelines (NRM 2002) and otherwise with ANCOLD guidelines, in particular with the guidelines on dam safety management (ANCOLD)	Note only (not a recommendation)	Rectified in works to date
5. It is desirable that the SunWater standards, notably DS13, be amended to better cover the spillways of dams including the energy dissipation zone. SOP 19 would benefit from inclusion of training on case studies of gravity dam failures and their causes and consequences, and on case studies of damages to gravity dam energy dissipators and of rock scour	DS13 was updated at the time and has been updated several times since	
6. It is desirable that SunWater review its procedures for assessing the potential for rock scour at its dams, particularly those dams with high specific power discharges (peak power per metre length of spillway crest). If not already applied, the recognized methodologies for estimating rock scour should become part of the assessment procedure for	Not specific to Paradise Dam and has not been actioned	

<p><i>those dams with high specific power discharges</i></p>		
<p><i>7. It is desirable that the potential for further rock scour at Paradise Dam is estimated carefully before the coming wet season and the work is reviewed by an independent peer reviewer recognized for knowledge of and experience in rock scour estimation methodologies. The peer reviewer should be involved from the outset so as to comment on the analysis scenarios and approach. The outcome of the work should include a “best estimate” result. As a minimum the work should cover a range of flood magnitudes and two configurations:</i></p> <ul style="list-style-type: none"> <i>• The configuration of the rock surface downstream of the dissipator as it will exist on completion of Phase 2 remedial works</i> <i>• The situation where the dissipator apron has been subsequently destroyed and removed by floodwaters.</i> 	<p>Task completed and included in EAP. Some postponed to post wet season during 2014.</p>	
<p><i>8. It is desirable that the stability analysis of critical dam monoliths is refined before the coming wet season and the work is reviewed by two independent peer reviewers, one recognized for knowledge of and experience in gravity dam stability analysis and one a recognized specialist in rock mechanics (unless a suitable person highly skilled in both fields can be found). The peer reviewers should be involved from the outset so as to comment on the analysis scenarios and approach. The outcome of the work should include “best estimate” results as well as results of traditional standards-based analyses. At this stage it appears the analyses should give consideration to:</i></p> <ul style="list-style-type: none"> <i>• The selection of analysis methodology and safety criteria for gravity dam stability</i> <i>• The outcomes of the rock scour analyses under the preceding point</i> <i>• The latest knowledge of foundation geology</i> <i>• A further review of the stabilizing forces provided by tailwater</i> 	<p>Stability revised based on Geotechnically drilling done for Safety review</p>	

<ul style="list-style-type: none"> Any proposed reliance on passive anchors, including the consideration that the load capacity cannot be monitored in the long term. 		
<p>9. It is desirable that the risk assessments be updated when results from the preceding two work items are available. Consideration should be given to these aspects of the risk analyses:</p> <ul style="list-style-type: none"> The results should be “best estimate” In addition to the failure pathway in the interim design report there should be a parallel failure pathway involving destruction of the dissipator apron by abrasion and the energy of the overflow An event tree branch for the probability of sliding, given deep scour to the dam toe, should be included The results from the scour and stability analyses should inform the probability of deep scour and the probability of sliding The reasoning underlying the selection of the risk analysis values needs to be fully documented. 	<p>Sunwater uses event trees as part of the risk assessment process</p>	
<p>10. It is desirable that the results of the updated risk assessment inform SunWater’s level of preparedness for the coming wet season and level of surveillance at the dam in the event of a flood. A precautionary approach should be taken having regard to these facts:</p> <ul style="list-style-type: none"> The analyses have wide uncertainty It is not reasonably practicable to know exactly what is happening in the energy dissipation zone during a flood event Public safety would potentially be at risk. 	<p>Completed using latest risk assessment in December 2013</p>	
<p>11. The reservations of SunWater’s independent peer reviewers regarding the value of analyses before the coming wet season, as proposed in our preceding advices, need to be fully heard and carefully considered.</p>	<p>Completed – risk assessment sent to TRP in October 2013</p>	

<p><i>Resolution of those reservations lies outside the scope of this review</i></p>		
<p>Second Term of Reference</p>		
<p><i>1. SunWater responded adequately prior to, during and immediately after the flood event. A precautionary approach was taken by activating the EAP for a potential sunny day failure event after the flood had subsided and until the emergency repairs had reduced risks to target levels</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>2. The available evidence indicates that SunWater maintained an excellent level of communication with the disaster management groups in the Bundaberg area. SunWater dam safety engineers provided authoritative information on the safety status of the dam and the disaster management groups relied on that information</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>3. Given the circumstances it faced, SunWater commenced the emergency repairs within a reasonable time. The methods for initiating releases, gaining access and determining the damage were reasonable given the time pressures</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>4. The application of risk assessment to assess the damages in a workshop of experienced professional people was a sound approach to the estimation of dam safety risks</i></p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p><i>5. An opportunity for improvement of practices/procedures for any future events exists in the risk assessment process with regard to:</i></p> <ul style="list-style-type: none"> <i>• Documentation of the risk assessment, particularly as regards the description of failure mechanisms and the reasoning which underlies probability values; Assigning “best estimate” risk values. If SunWater sees reasons to take a precautionary approach, that should be done after the “best estimate” risk assessment results are available</i> <i>• Use of event trees primarily, but also fault trees if appropriate, to fully define failure mechanisms;</i> 	<p>Sunwater uses event trees as part of the risk assessment process and have improved the Risk Assessment process significantly since 2013</p>	

<p><i>and Bolstering engineering judgment by science and world experience of dam performance to the maximum practicable extent</i></p>		
<p>6. Given what is now known about the performance of the dam in floods, there would appear to be an opportunity of improving SOP 42, and possibly other guidance documents, with respect to:</p> <ul style="list-style-type: none"> • Ensuring that a dam safety engineer makes a site inspection as a matter of urgency after a report of damage which is potentially a dam safety incident as defined by the regulator • Specifying that “time to notify” under DS 2 of the development permit conditions runs from the date of the engineer’s inspection provided the damage is confirmed as a “dam safety incident” • Specifying who is responsible for initiating notification of the regulator and seeing that it is made within the required time of seven days. 	<p>Completed and amended</p>	
<p>7. There is an opportunity to improve procedures by SunWater training its personnel to enter sufficient words in the “Message” field of Communication Records to enable others to comprehend the subject of the communication</p>	<p>Completed in EEC and Dam Safety Training material at the time</p>	
<p>Third Term of Reference</p>		
<p>1. Given the circumstances it faced, it was not reasonably practicable for SunWater to reduce the time required for completion of the emergency repairs</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>2. The emergency repairs were an appropriate means of progressively reducing risk</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>3. The activation of the EAP for a sunny day failure scenario was a reasonable, though precautionary, means of risk mitigation and it was not reasonably practicable to improve the mitigation measures within the time available without detriment to other critical activities</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>

<p>4. The EAP should be revised to allow for the risks which are now known to exist at Paradise Dam. In particular, response plans should be devised for possible future damage scenarios</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>Fourth Term of Reference</p>		
<p>1. The EAP covers all of the content required by the dam safety regulator's guidelines, though not always as fully as is desirable.</p>	<p>Note only (not a recommendation)</p>	<p>Rectified in works to date</p>
<p>2. If the advice under the first Term of Reference is followed, it is desirable that the EAP is revised to take account of the findings of the analyses proposed under that TOR.</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>3. It is desirable that SunWater work together with the disaster management groups in an effort to make the EAP more user friendly and to maximise the effectiveness of evacuation.</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>4. It is desirable that the EAP be revised to better deal with redundant systems for emergency management.</p>	<p>Sunwater has revised its emergency management response since 2013 and has considered the need for redundant systems</p>	
<p>5. It is desirable that the EAP be revised to provide better information on assets and resources which may be required for emergency management</p>	<p>EAP was revised in October 2013 and approved by the Regulator and has been updated annually since, including major revisions to take into account legislation changes and learnings of other events such as Callide Valley in 2015</p>	
<p>6. It is desirable that the EAP be reviewed to remove any content that is not applicable to Paradise Dam</p>	<p>EAP was revised in October 2013 and approved by the Regulator</p>	
<p>7. It is desirable that there be a list of acronyms and their meaning immediately after the table of contents</p>	<p>This was added to the EAP in October 2013 and approved by the Regulator</p>	
<p>8. It is desirable that the EAP be revised to make clear statements about the need for continuous attendance of surveillance personnel at the dam</p>	<p>Implemented in EAP revision in October 2013</p>	
<p>9. It is desirable that the EAP be revised to make clear statements about the urgency for inspections by a dam safety engineer</p>	<p>Flow charts amended and updated</p>	

<p>10. It is desirable that the EAP be revised to give better guidance on the reporting by personnel at the site of changed conditions at the dam</p>	<p>Was amended in Dam Safety courses</p>	
<p>11. It is desirable that consideration be given to revision of the EAP to give guidance on the impact of releases from the dam on downstream access and residents</p>	<p>Completed – downstream residents were added to the EAP for contact</p>	
<p>12. It is desirable that the EAP be revised to provide more useful information on available access modes and routes to the dam</p>	<p>Alternate access routes and travel distances were added to the 2013 EAP amendment</p>	
<p>13. It is desirable that the EAP be revised to provide a more accurate definition of incremental flood effects</p>	<p>EAP updated to reflect failure and non failure flood cases in 2013 amendment</p>	
<p>14. It is desirable that consideration be given to the value of 2D inundation modelling and to the preparation of more accurate mapping on which to plot inundation extent</p>	<p>At the time it was decided to not undertake 2D modelling but this has since been completed</p>	
<p>15. It is desirable that the EAP be revised to remove any inappropriate or outdated references</p>	<p>Completed in EAP update in 2013</p>	
<p>Fifth Term of Reference</p>		
<p>1. It is desirable that the feasibility of improvements at the dam, and to other infrastructure, be investigated as part of the Phase 3 work. These are improvements which may assist dam safety management generally and which may reduce the time required for any future remediation in particular. Some key matters to be examined are:</p> <ul style="list-style-type: none"> • Increasing the flow capacity of culverts on the normal southern access road to the dam to reduce the likelihood of wash-outs • Improvements to the right bank access at the dam that would avoid destruction of the access in every large flood • Improvements that could provide early access to the left bank at the dam for a) inspecting personnel and b) heavy equipment needed for remediation work • Subject to the outcome of the preceding point, provision of safe access down the left bank to the left end of the dissipator apron 	<p>Culverts were installed to facilitate better access to the Dam and the other matters were deferred for inclusion in the Dam Safety review and comprehensive risk assessment as part of the Phase 3 work</p>	

- *Measures to prevent ingress of gravel or other debris to the environmental flow gate chamber*
- *Measures to safeguard the hydraulic rams that are designed to open the environmental flow gates*
- *Measures to better protect the electric power system used to operate release facilities and to reduce the time required for repair in the event power is lost in floods*
- *Improvements which would allow a greater release discharge without disrupting any potential future remediation work in the energy dissipation.*

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