How Safe Is "Safe" - The Journey of PNCC as a “Small" Owner of Two Large Dams

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Abstract –

Palmerston North City Council (PNCC) owns two large dams namely Turitea Upper Dam and Turitea Lower Dam which impound water sufficient to meet approximately 60 to 70% of the city’s annual potable water demand. This paper covered the journey PNCC commenced from early 2000 to prepare for the impending NZ Dam Safety Scheme, including reflection on what had been done in the past, the dam safety issues and the path to resolution including adoption of the improvement initiatives in our LTP. It also discussed the findings from the dam safety activities, the impact of the revocation of Dam Safety Regulations in 2015 and the challenges of determining how to manage the dams in the interim and how we address the technical resourcing issues as a small dam owner.

Key Words

Turitea Dam, Dam Safety Scheme, Revocation, Regulations, Structural performance review

Introduction

Palmerston North City Council (PNCC) owns and operates two dams namely Turitea Upper and Turitea Lower Dams which provide principle storage as municipal water supply. Both dams are built on Turitea Stream and are classified as “Large Dam” according to the current Building Act.

Figure 1, Location map for the Turitea Dams, Tararua Ranges, Palmerston North

The Turitea Lower Dam was originally constructed in 1907 and has been raised twice, in 1913 from 7 m to 15 m, and in 1997 to 22 m. The enlargement work which was completed in 1997 has

shifted it from a Concrete wedge Dam to a Concrete faced rock-fill embankment Dam, which is the first for a New Zealand site. This work also has addressed the historic stability issues.

Upper Turitea Dam is a variable radius arch dam with a gravity thrust block on the upper left Abutment built in 1957. It is the largest dam in New Zealand for the same sort.

The dimension details are shown in the table below:

	Upper Dam	Lower Dam
Dam height	39 m	22 m
Crest length	85 m	80 m
Spillway crest width	18 m	22 m
Reservoir capacity at spillway crest level	1,700,000 m3	140,000 m3

Table 1, Summary of Upper and Lower Turitea Dam details

The storage in the dams supplies 60% to 70% of annual water supply to Palmerston North City. The rest of water is supplemented from deep bores spread on four sites in the city.

Figure 2, Turitea Upper Dam when is overflowing

This paper is to cover the journey of Palmerston North City Council commenced to prepare for the impending Building (Dam Safety) Regulations in early 2000 up to the stage of almost ready to its coming into force, to the revocation of the Regulations on 30 June 2015 and the impact to us. It will also discuss the findings from our dam safety activities, the challenge of finding the directions after the shelving of the Regulations as well as the technical resource constrains and how we deal with it.

NZ Dam Safety Scheme

New Zealand dam safety supposed to be regulated by Building Act 2004 and the Building (Dam Safety) Regulations 2008 (the Regulations) which has never come into force.

The Dam Safety Scheme (the Scheme) was established in 2004 under the Building Act, but requires Regulations to bring it into effect. These Regulations were promulgated in July 2008, and supposed to come into effect in July 2010. However, the date had been deferred a few times firstly to 1 July 2012, secondly to 1 July 2014, then to 31 March 2015 and finally was revoked in 30 Jun 2015 without prior notice or consultation from Government.

The Scheme was a risk-management regulatory system for Dams in New Zealand. It sets the threshold for classifiable, referable and large dam. The two dams that PNCC owns are both classifiable and are large dams which are subject to the Scheme therefore the potential impacts are supposed to be managed by implementing an approved annual audited Dam Safety Assurance Programme (DSAP). It also has the definitions for dangerous dams, earthquake and flood prone dams.

Under the requirement of the Regulations DSAP must have the following six elements for High and Medium Potential Impact Classification (PIC) dams:

- Surveillance – what and how often
- Annual dam safety review (ADSR)
- Comprehensive dam safety review (CDSR)
- Emergency Action Plan
- Appurtenant structures – inspection exercise and testing
- Deficiencies management - investigation, assessment and resolution

The Regulations requires the dam owners must classify the PIC and review it PIC every five years. The PIC is based on assessed damage level, population at risk and likely estimated potential loss of life under the dam break scenarios.

A flow chart shows the requirements of the Scheme for High and Medium Dams is shown as below:

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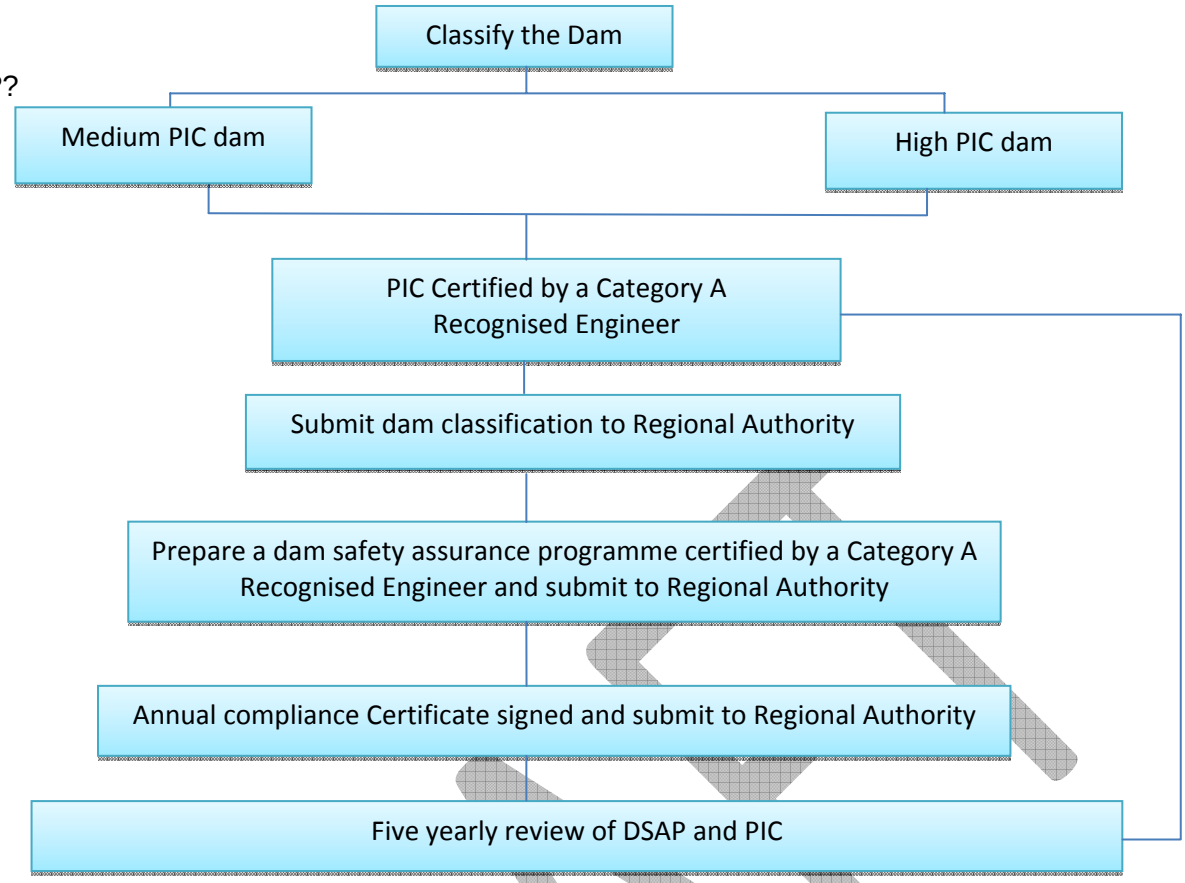


Palmerston North City Council dam safety activities

PNCC has been working on the Scheme as soon as the Scheme was established all the way through to the stage of almost ready for it coming into force by 2014.

Some of the work PNCC has been doing on both dams includes:

- Monthly surveillance observation/post-earthquake inspection
- Annual deformation survey
- Annual dam safety review
- Dam PIC study including dam break scenario modelling and inundation mapping in year 2002 and 2012
- Five yearly Comprehensive Safety Reviews
- Dam Safety Policy- signed by CEO
- Dam Safety Assurance Programme
- Dam Emergency Action Plan prepared and exercised
- Dam Operation, maintenance and surveillance manual in place and updated regularly
- Installation of survey monuments and survey marks for the upper dam deformation survey
- Structure performance reviews on both dams (to be completed yet)

Potential Impact Classification 2012 & 2013

Prior the Regulations was introduced, an initial dam break study and Potential Impact Classification assessment was carried out by Tonkin + Taylor (T+T) in 2002. The Upper and Lower Turitea Dams were assigned to High and Medium PIC's respectively. The Regulations introduced a more

prescriptive method for PIC assessment. The PIC was reassessed in two stages in 2012 and 2013 by T+T in according with the Regulations.

The Stage One work confirmed the Uppder Dam as High PIC subject to the results of further analysis while the Lower Dam may potentially to be a High PIC.

The Stage Two work includes using comprehensive hydraulic models namely Mike 21 as 2D model to simulate the breach flows and using Mike 11 as 1D model to check the effects of major hydraulic structures, such as bridges were reasonably represented.

The definitions of Potential Impact Category (PIC) from the New Zealand Society of Large Dams (NZSOLD) 2000 were adopted detailed as below:

Potential Impact Category	**Potential Incremental Consequences of Failure**	
	Life	**Socio-economic, Financial and Environmental**
High	Fatalities	Catastrophic damages
Medium	A few fatalities are possible	Major damages
Low	No fatalities expected	Moderate damages
Very Low	No fatalities	Minimal damages beyond owners property

Using the above criteria and the methodology specified in the Regulations, T+T derived that they do “not expect that it is highly likely that two or more lives would be lost as a result of a Lower Dam failure” while population at risk as a result of the Upper Dam failure or Cascade Lower Dam failure as a result of the Upper Dam failure is estimated of **59 to 127 people**.

The conclusions from T+T are:

- The **Upper Dam** should remain classified as **High** PIC
- The **Lower Dam** should remain classified as **Medium** PIC

WILL THE DAM BREAK?

The bright site is the nature of the Turitea Upper Dam is Concrete Arch Dam which is considered very stable and the cases of a concrete Arch Dam failure historically are very rare. The Dam design and construction was reasonably robust. Previous studies showed it will stand under the design seismic condition.

However, if it failed, it only takes 20 munities for the water to reach the first affected property, meaning we do not have much time to response.

WHAT WE DO?

The Council communication officer believed we should inform the affected residents straight away. But the question is what we can tell them before we are confident with the likelihood of failure.

It was then decided that the Council will get the Dam structural performance reviewed before any engagement with the community. However, there should be a note in the LIM report for the affected properties.

Comprehensive Safety Review 2013

PNCC had carried out four comprehensive safety reviews to the Turitea Dams. The most recent one commenced in parallel with the PIC and was completed by DamWatch in 2014.

DamWatch come up with 16 recommendations on the Upper Turitea Dam 18 recommendations on the Lower Turitea Dam plus five recommendations on the DSAP!

No.	Recommendation	Report ref.
Upper Turitea Dam		
UD-1	Because the PMF is a required design load for the High PIC Upper Dam, we recommend that PNCC commissions an experienced New Zealand hydrologist to carry out a PMF estimation using the latest recognised techniques.	4.1.2, 7.2.1
UD-2	Because the MCE or 1:10,000 AEP earthquake is a required design load for the High PIC Upper Dam, we recommend that PNCC commissions an experienced New Zealand seismologist to carry out a site specific hazard study that considers nearby faulting and updates to the National Seismic Hazard Model. As a minimum this needs to produce loads for 1:150, 1:500, 1:2,500 and 1:10,000 AEP earthquakes with comment given on the MCE.	4.2.4, 7.2.2
UD-3	Clear vegetation from Upper Dam left and right abutment contact, for at least 5 m from the dam face, to facilitate inspection of the contacts.	6.2
UD-4	Undertake a dive inspection of the Upper Dam stilling basin to assess current condition.	6.2
UD-5	Following review of PMF calculations it is recommended that parapet walls of sufficient height to prevent PMF overtopping eroding abutments be considered on both the left and right sides of the dam.	7.2.1
UD-6	We recommend that the Upper Dam is analysed using modern dynamic analysis techniques and the latest seismic load knowledge to demonstrate that it does indeed meet criteria.	7.2.2
UD-7	Whilst the effects of sediment are unlikely to dominate the stability of the Upper Dam, it is recommended that the extent of sedimentation be determined and accounted for in the next stability assessment update.	7.2.2
UD-8	Assess the Upper Dam thrust/gravity block for stability to confirm that there is not a mechanism where arch support can be lost by its sliding or uplift.	7.2.2
UD-9	Pending a specific study on the stability of the Upper Dam thrust/gravity block commence monitoring of seepage from the under-drain and investigate the drain's condition.	7.2.2
UD-10	Assess the Upper Dam abutments for potential kinematic joint/block or massive breakout failure mechanisms.	7.2.2
UD-11	Assess the Upper Reservoir for earthquake induced reservoir slope failure and subsequent Upper Dam overtopping.	7.2.2
UD-12	It is recommended that the performance characteristics of the mini hydro generators and bypass are investigated for dam dewatering. A dewatering plan should be developed on this basis.	7.2.3
UD-13	For the purpose of ongoing dam safety and surveillance it is recommended that Upper Dam reservoir level is plotted in absolute R.L. by applying an offset determined by the R.L. at spillway crest level.	8.1.1
UD-14	Examine the historical record of Upper Turitea reservoir level to determine the maximum reservoir loading. This is important context for ongoing dam safety and surveillance.	8.1.1
UD-15	Install a water level staff gauge (reading in R.L) at the Upper Turitea reservoir for the purpose of emergency inspections and ongoing calibration check of the radar level sensor.	8.1.1

No.	Recommendation	Report ref.
UD-16	It is recommended that consideration be given to technology/methods that will allow a timely and precise understanding of dam deformation performance to be gained post-earthquake.	8.1.4
	Lower Turitea Dam	
LD-1	Perform a dry inspection of the Lower Dam Hypalon joint and check the need for adding further mastic or repair. This should be repeated every five years.	6.3
LD-2	Keep the grass on the downstream slope of the Lower Dam short to improve inspection conditions, and remove vegetation from the spillway chute joints.	6.3
LD-3	Improve monitoring of total seepage flow at the Lower Dam.	6.3, 8.2.3
LD-4	Monitor the Lower Dam standpipe piezometers monthly and replace the cap of piezometer PZ2.	6.3, 8.2.4
LD-5	Some rock erosion protection from the natural slope to the right of the spillway chute has fallen out of position. It is recommended that this be repaired to prevent erosion behind the chute wall.	6.3
LD-6	It is recommended that an inspection be made of the stilling basin and downstream to check for damage and erosion every five years or after floods.	6.3
LD-7	It is recommended that a floating boom be installed to keep the spillway entrance clear of tree debris.	7.3.1
LD-8	It is recommended that the stability of the slope above the spillway to be assessed in detail and slope remediation works carried out if a risk of spillway blockage is concluded to be highly likely. An engineering geologist experienced in rock slopes and a rock slope engineer should review the slope.	7.3.1
LD-9	Given the variability in previous Lower Dam flood estimates and the likelihood that the PIC becomes High in the near future; it is recommended that the PMF be re-estimated by an experienced New Zealand hydrologist and the dam's ability to pass safely be checked.	7.3.1
LD-10	We recommend that the Lower Dam stability (earthquake and post SEE-aftershock shaking) is analysed using modern analysis techniques, the latest seismic load knowledge and a rigorous assessment of damage under seismic loading to demonstrate that it does indeed meet criteria.	7.3.2
LD-11	The Upper Dam recommendation for an experienced New Zealand seismologist to carry out a site specific seismic hazard study using the latest recognised techniques should also be carried out for the Lower Dam.	7.3.2
LD-12	Assess the Lower Reservoir for earthquake induced reservoir slope failure and subsequent Lower Dam overtopping. This should incorporate consideration of the potential for coincident Lower Dam spillway cut slope failure and blockage of the spillway.	7.3.2
LD-13	Assess the performance characteristics of the Lower Dam scour offtake for the purpose of emergency dam dewatering. The outlet must be maintained and tested regularly to ensure ongoing reliable function. Operating instructions must be provided in the dam O,M&S manual. Reliable operation in the event of a large earthquake must be assured.	7.3.3
LD-14	For the purpose of ongoing dam safety and surveillance it is recommended that Lower Dam reservoir level is plotted in absolute R.L. by applying an offset determined by the R.L. at the current reference level.	8.2.1

	Recommendation	Report ref.
LD-15	It is recommended that the historical record of Lower Turitea reservoir level be checked for accuracy/completeness and the maximum historical reservoir loading be determined. This is important context for ongoing dam safety and surveillance.	8.2.1
LD-16	Install a water level staff gauge (reading in R.L) at the Lower Turitea reservoir for the purpose of emergency inspections and ongoing calibration check of the radar level sensor.	8.2.1
LD-17	Locate the record of supposed failure of the Lower Dam pneumatic piezometers or carry out a functionality test of the instruments by an instrumentation specialist.	8.2.4
LD-18	Improve the Lower Turitea Dam deformation survey to include vertical measurement of concrete dam marks (P4, BOLT 5, P7, P8, P9 and P10), and horizontal measurement of the embankment dam marks (BM's 1 to 8).	8.2.5
PNCC dam safety activities		
DSAP-1	It is recommended that Palmerston North City Council closely monitors development downstream of the dams, with respect to dam break inundation extents, to ensure the decision to elevate the Lower Dam PIC from Medium to High is made in a timely manner. It is likely that any increment in population at risk (depth of inundation > 0.5 m), particularly in the reaches closest to the dams, will result in a High PIC being required.	2.4
DSAP-2	Update the routine field inspections sheets for Upper and Lower Dam to reflect monitoring for failure modes.	8.1.5
DSAP-3	Once EAP revision is complete it is recommended that it be exercised involving the key agencies and authorities that would be involved in a dam safety emergency response.	9.4.3
DSAP-4	Due to the high seismic hazard of the Turitea area and high hazard potential of the Upper Dam, it is recommended that options for real time monitoring and early warning systems be investigated, to allow timely notification (and if necessary, evacuation) of population at risk.	9.4.3
DSAP-5	It is recommended that the following outstanding items be addressed as part of the current development of a formal DSAP; - formalisation of ongoing surveillance activities including a process to ensure analysis, quality assurance and follow up of routine monthly surveillance data collected - formalisation of requirements for inspection of appurtenant structures, including testing of gates and valves that contribute to reservoir safety - formalisation of procedures for the investigation, assessment and resolution of dam safety deficiencies	9.4.3

Table 1, Recommendations from the 2013 CSR

Actions followed the 2013 CSR recommendations

To date, most of the recommendations have been addressed or well underway.

Among the 39 recommendations, the following recommendations are considered to be critical given the population at risk:

- *UD-6: Recommend that the Upper Dam is analysed using modern dynamic analysis techniques and the latest seismic load knowledge to demonstrate that it does indeed meet criteria.*
- *UD-8: Assess the Upper Dam thrust/gravity block for stability to confirm that there is not a mechanism where arch support can be lost by its sliding or uplift.*
- *UD-10: Assess the Upper Dam abutments for potential kinematic joint/block or massive breakout failure mechanisms.*

In preparation of the above tasks, the following investigation has been carried out:

- Site Specific Response Spectra for Turitea Dams Safety Review to determine the design earthquake load – GNS 2014
- Turitea Dams flood routing analysis to assess the Probable Maximum Flood and simulate the water level I the reservoirs, spillway discharge, free board to the dam crest and the potential debris blockage impact – T+T 2014
- Upper Turitea Dam Geotechnical and Engineering Geological Assessment - T+T 2015
- Divers inspection on the stilling basins on both dams to assess the conditions
- Divers inspection of the lake sedimentation level at the Upper Dam face

On completion of the above investigation, T+T was selected to carry out the Dam Structural Performance Review through a RfP process. The review is to include all the tasks identified in the CSR recommendations.

The Dam Structural Performance Review

The Dam Structural Performance Review is a three year package which was determined by the budget availability. However we managed to source additional budget and it is expected to be completed by 30 June 2017.

To date the Upper Dam Structure performance assessment stage one using linear time history analysis has completed with the following observations:

1. Stresses under the static loading condition are generally within the allowable range expected for the concrete (both tensile and compressive). There are some high tensile stresses on the downstream face under winter thermal loading. However, these are localised to the surface and would if anything cause some limited opening of the vertical construction joints.
2. Stresses for the IDF loading case are marginally higher than for the static loading case, but are within allowable limits. The same conclusions as above regarding tensile stresses for winter thermal loads are made.
3. Stresses for the OBE are higher than the static loading case but are generally within the allowable limits for dynamic loading. There are some moderately high arch-tensile stresses at the crest which are well within the concrete strength performance criteria for the intact concrete. However they may exceed the strength of the construction joints for short periods of time. This could cause some opening of joints and redistribution of stresses although this is not considered significant given the available arch and cantilever stress capacity elsewhere.
4. For the SEE loading case, for Stiffness Case 1, the stresses in the arch (both compressive and tensile) are significantly higher than for the other load cases. Compressive stresses are still within the acceptable limits, however tensile stresses (both arch and cantilever) exceed the concrete strength performance criteria. Significant cracking or opening of construction joints during SEE loading is predicted based on these results. While only a single stiffness sensitivity case has been undertaken for the SEE load case, this overall conclusion is

considered to be appropriate and would not be affected by the results of the other stiffness sensitivity cases.

This is the first time that the Upper Dam is identified with a potential deficiency!

However, the calculated maximum arch deflections under SEE loading are in the order of ±20mm which is relatively small in comparison to other arch dams.

Therefore T+T believes:

“Under extreme loading (such as the SEE) the dam is still considered to meet performance criteria provided collapse does not occur even with damage.”

“Given the relatively low calculated displacements in this linear analysis, it is possible that even with extensive cracking of the arch, failure and uncontrolled release of the reservoir may be unlikely for the SEE, but further analysis would be required to confirm this.”

A peer review has been carried out by Larry Nuss from Colorado and the above observations and comments were from the update version followed his comments.

SEE is the abbreviations for Safety Evaluation Earthquake. For High PIC dam it to be set as the 84th percentile level for the Controlling Maximum Earthquake (CME) if developed by a deterministic approach, and need not exceed the 1 in 10,000 AEP ground motion developed by a probabilistic approach.

As recommended by T+T, a further sensitivity to Concrete Tensile Strength analysis was carried out as the first attempt to confirm or rule out a potential deficiency. The outcome from this analysis could not rule out the potential deficiency.

Due to all analyses are based on the assumption of the minimum compressive/tensile strength specified in the historical drawings, and the actual concrete strength may be higher due to aging of the concrete. If the concrete strength is higher than the assumed value to certain extent, the potential deficiency will be ruled out. Therefore a coring sampling and laboratory testing on concrete and rock is contracted out and we are still waiting for the outcomes.

- Structural review in ...

Apart from the above work, the following actions have also been taken to address the CSR recommendations:

- Installed water level staff gauge on both dams
- Cleared the vegetation around the Upper Dam abutments and the Lower Dam face areas to make it easier for visual inspections
- Lower Dam pneumatic Piezometers are repaired and the readings are included in the monthly surveillance inspection
- A floating log boom was installed on the Lower Turitea Lake to keep the spill way entrance clear from debris
- Repaired the fallen and out of placed rock behind the chute wall with additional rocks and concrete to protect the spillway chute
- Pipe extensions installed to enable the measuring of seepage rate from the Lower Dam
- EAP was excised
- The DSAP recommendations were largely addressed
- The Community Communication Strategy was scoped in the Structural Performance Review as one specific task

Dam Safety and Council LTP

Prior 30 June 2015, Council has been very supportive on Dam Safety Policy and DSAP due to the pending Regulations and the high PIC of the Upper Dam.

An operation programme was adopted in the 2015 LTP to reflect the cost to meet the obligations set in the Regulations and all the further follow ups to the 2013 CSR recommendations. The annual budget is between $35,000 and $83,000 depending specific takes and their cost.

WATER - OPERATING PROGRAMMES

ID-NAME	GROWTH	LOS	10YP 2015/16 $'000s	10YP 2016/17 $'000s	10YP 2017/18 $'000s	10YP 2018/19 $'000s	10YP 2019/20 $'000s	10YP 2020/21 $'000s	10YP 2021/22 $'000s	10YP 2022/23 $'000s	10YP 2023/24 $'000s	10YP 2024/25 $'000s
898-Water Supply Development Plan	50%	50%	45	-	-	-	-	-	-	-	-	206
1052-Turitea Dams - Implementation of the Dam Safety Assurance Programme	0%	100%	80	83	67	70	34	35	37	80	83	58
1246-Three Waters Public Education - Water	0%	100%	11	11	12	12	12	13	13	14	14	15
TOTAL			**136**	**94**	**79**	**81**	**46**	**48**	**50**	**94**	**97**	**279**

A capital project is also adopted to improve the Dam dewatering capacity.

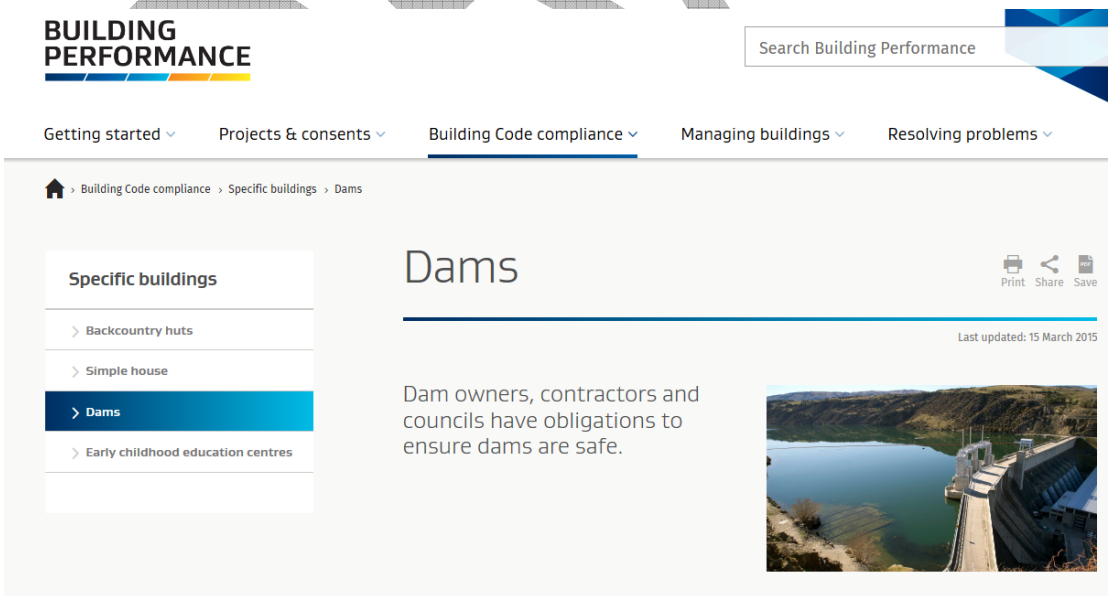
The impact from the revocation of Regulations

The pending Regulations coming into force date certainly has been a huge drive on the PNCC dam safety activities.

The Regulation has provided not only the direction and obligations but also very specific with the approach and methods to ensure the dam is operated safely. As a Council officer in charge Dam safety, I found it was a lot easier to have such Regulations to follow and had no trouble to allocate appropriate budget.

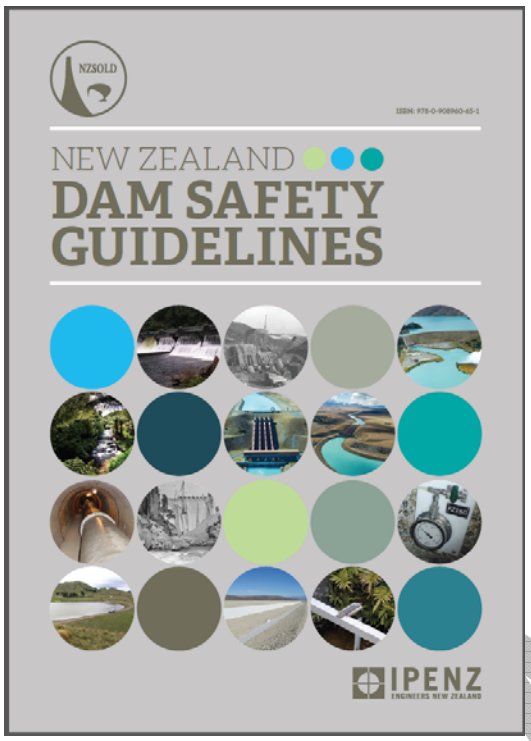
However, without any signal or consultation the regulation was revoked on 30 June 2015 one day before the latest coming into force date. The reason given was RMA is the better place to regulate the Dam Safety Scheme.

Below is the screen shot from the current MBIE website Dam page:

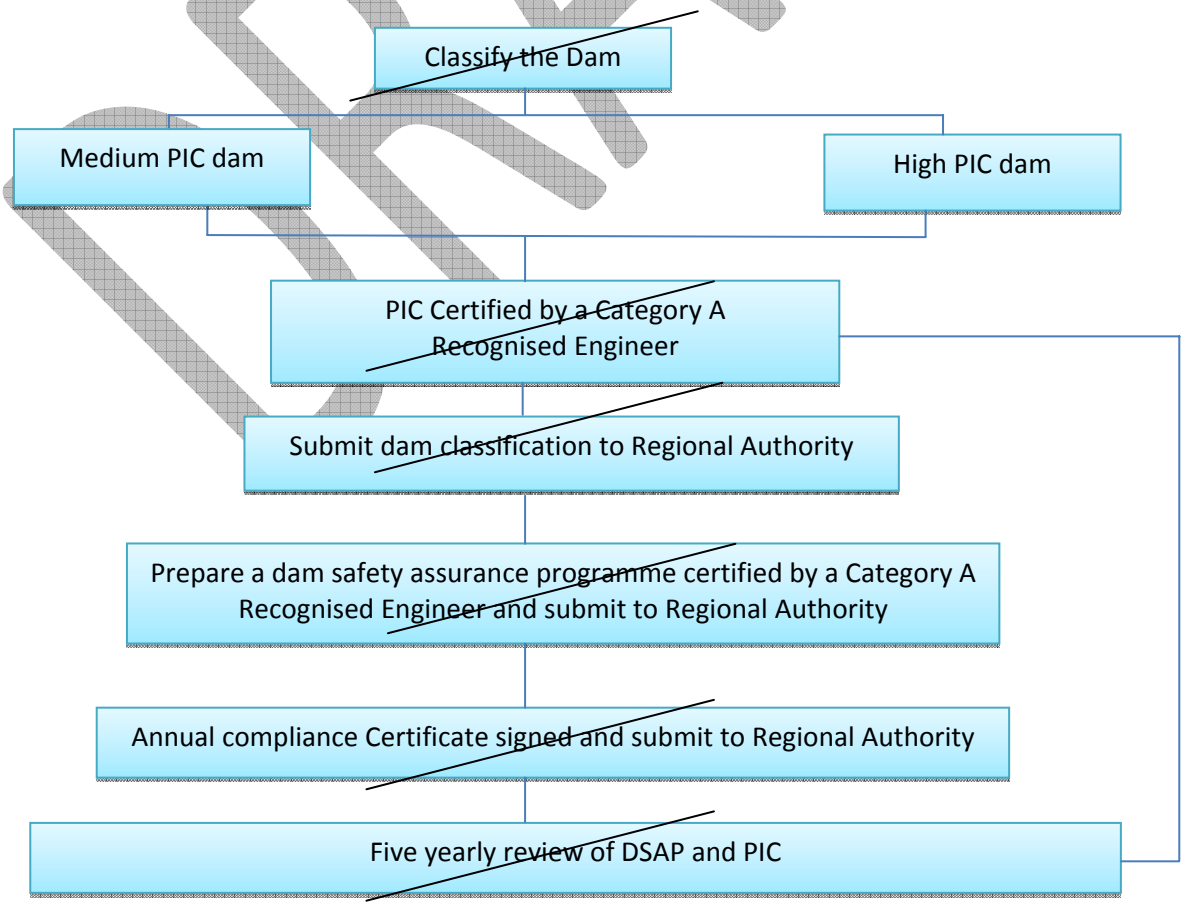


The Council's responsibility and obligations for the Dam safety remains un-changed However the revocation of the Regulations leaves the Council to a position that lost all the rations behind the work we have been carried out.

MBIE has the link of NZSOLD Dam Safety Guidelines as “Further information” which doesn’t have any legal effect. Furthermore, the guidelines were written to follow the Regulations and has been using the definitions in the Regulations also refers the Regulations all the times.



The following frame works are no longer legally required!



All the work that we have done so far are under the Regulations and employing the methods specified in it including the current structural performance review. Are they still valid and will they need to be reviewed? All the cost occurred were necessary?

We don't have clear direction apart from carry on what we are doing now. However, is the level of work adequate?

Where are we heading to for now

Before the government decided how to regulate the Dam Safety operation, PNCC will not change its Dam Safety Policy and will still be following the DSAPs carrying on the tasks set out on the DSAP!

THE BEST ENGINEERING PRACTICE

But might get challenged

Our assumption is the principle of the Dam Safety Scheme in unlikely to be hugely changed but currently still seeking the options to regulate it under the RMA.

Risk will still be our focus and the Dam surveillance survey, annual safety review and five yearly comprehensive review etc. will still be carried out.

The potential deficiency from the Structure Performance Review had added a bit of uncertainties. We understand the risk is high due to the catastrophic consequence, however the potential deficiency was for 84 percentile of about 1 in 10,000 earthquake and T+T recommended the likely hood of the dam collapse and the release of content is rare.

It is still too early to make any decisions so far, however the following measures could be the options if any deficiencies are confirmed:

- Report to the Council with the findings followed by comprehensive community communication strategy considering the Consultant's advice.
- The capital programme for Dam Dewatering System Improvement may need to bring forward
- Some remote monitoring instrument might be an option plus an alarm system
- We trust the T+T report is pretty robust however further model calibration might be required prior any strengthening option is considered

More technical input from consultants will also be expected.

Issues being a small council with limited resource

As stated previously, we have not experienced and budgetary difficulties given that the Regulations behind the scene. Lack of technical expertise on geotechnical engineering and Dam structure and safety have been the constrain given that we are a small Council.

In PNCC

Water Supply Asset Engineer = Dam safety Engineer
Water Treatment Plant Operator = Dam Surveillance operator
Survey Officer = Surveillance deformation surveyor & Survey data processor

A few staff have attended some dam safety trainings and a capable for surveillance survey and full fill with the tasks set in the DSAP. When comes to specific technical issues, we have to seeking for external help.

To address these constrains, PNCC has engaged Damwatch which is now Dam Safety Intelligence (DSI) to provide technical expertise which we found it is very cost effective. The agreement with DSI is on demand and it rolling year by year.

During the post-earthquake Dam inspection followed the Kaikauro 7.8 Riced scale earthquake last November, a significant seepage was observed in Lower Dam.

Inspection Date	Inspector	Review Date	Reviewer	Comments	Lower Dam seepage (l/min)	Actions	Action date
31/10/2016	Joshua McIncoe	1/11/2016	D.Luo	1 Larg logs on the spillway; Road Repaire in progress on Road	2.5	Has been cleared yesterday afternoon!	
14/11/2016	S. G. Mahoney	18/11/2016	D.Luo	Lower Dam seapage increased	27.0	contacted DamWatch suggesting to monitor it on daily basis for a week	today
18/11/2016	Joshua McIncoe	18/11/2016	D.Luo	Lower Dam seapage increased	48.0	forward to Damwatch	4:00pm
19/11/2016	Joshua McIncoe	19/11/2016	D.Luo	Lower Dam seapage increased	18.0	Back to normal	9:00 a.m.
9/12/2016	S. G. Mahoney	12/12/2016	D.Luo	Lower Dam seapage settled	11.0		
10/01/2017	S. G. Mahoney	20/01/2017	D.Luo		11.5	N/A	
22/02/2017	Joshua McIncoe	24/02/2017	D.Luo	Does Power Line from mini hydro to Plant get inspected?	8.5	Mark J advised it is done annualy and is over due now. (last done Dec 2015)	Mark will get is organised in the next couple weeks.

Table 1, Turitea Dam Monthly Surveillance data log sheet

It has been raining however that amount of seepage was not expected. Dam Safety Intelligence was advised instantly. DSI was surprised with the amount of seepage and suspected it was the earthquake related. Given the nature of the dam is a concrete face rock-fill embankment dam, and the seepage was clear they advised us to keep monitoring it.

The initial report was received on Friday and it was decided the duty operator will do more seepage monitoring in the weekend. The DSI had made an on call and a standby engineer arrangement to cover the weekend to prepare for any actions are required.

Lucky the seepage went down and eventually back to normal.

Dam Safety Intelligence previously Damwatch had had some critical technical inputs during the RFP process for the Dam Structural Performance Review and the EAP exercise.

Conclusions

As a small Council we will be facing more challenge of lack of resource and without any regulations to back up us. We have to be risk focused and carry on the best practice to full fill our obligations to ensure the dam is operated safely.

References

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NZSOLD (2015). New Zealand Dam Safety Guidelines
Tonkin+Taylor (2016). Upper Turitea Dam Structural Performance Review
Tonkin+Taylor (2013). Turitea Dams Review of Potential Impact Category