

Rotorua Lakes Council
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Attention: Greg Manzano

Dear Greg

Linton Park East Flood Detention Pond - Dam Safety Assessment

- Proposed remedial works to address dam safety deficiencies

1 Purpose

The purpose of this report is to explain the context and justification for the decision by Rotorua Lakes Council (RLC) to upgrade the existing flood detention dam at Linton Park East under urgency, using the emergency provisions of the Resource Management Act (Section 330).

2 Background

2.1 The existing dam

The existing stormwater detention dam in Linton Park East was constructed in 1998 for the purpose of flood detention to protect downstream property and infrastructure. The original design intent was to attenuate the peak outflow from the dam to less than 10 m³/s in the 100-year ARI flood. The existing dam comprises a 420 m long, L-shaped, earthfill embankment, up to 3.0 m high. A corrugated aluminium culvert conveys low-level flows, and a lowered section of the dam embankment protected with geotextile is designated as an auxiliary spillway to convey flows in larger flood events.

2.2 Requirement for dam safety assessment

The New Zealand Society on Large Dams (NZSOLD) publishes the New Zealand Dam Safety Guidelines (DSG) (New Zealand Society on Large Dams (NZSOLD), 2015). The current version of the DSG was published in 2015, and describes the accepted industry practice for dam design, construction, and ongoing dam safety management. There are several important components of ongoing dam safety management that are described in the DSG and addressed in this report.

A fundamental principle is that the consequences of a dam failure should be understood so that appropriate design, construction, and management actions can be applied to protect people, property, and the environment. For some dams, failure can cause widespread environmental and property damage and put lives at risk.

Module 2 of the DSG describes a process for assessing the potential consequences of dam failure, and assigning dams a Low, Medium or High Potential Impact Classification (PIC). A recent assessment

(Tonkin & Taylor Ltd (1), in Preparation) has identified Linton Park East as High PIC. The PIC sets the recommended standards for dam design and ongoing dam safety management whereby the standards are commensurate with the consequences of failure i.e., dams with High PIC have the highest standards for design and ongoing management to keep risk of dam failure to an acceptably low level, by ensuring the probability of failure is extremely low.

An important component of ongoing dam safety management, as described in Module 5 of the DSG, is to undertake regular dam safety assessments of existing dams and identify dam safety issues and deficiencies. The following sections describe the outcomes from a dam safety assessment of the existing Linton Park East dam.

3 Dam safety assessment

In assessing the condition of the existing dam, the following tasks have been completed:

1 Review of original design drawings, as-built drawings, and consent documentation

The drawings and documents indicate that the dam was designed with the intent to be able to pass a design flood with a peak inflow of 17 m³/s and peak outflow of 9.8 m³/s through a combination of the corrugated aluminium culvert and an auxiliary reinforced grass spillway over a lowered section of the dam embankment. The embankment was designed as a homogeneous earthfill dam with no specific provisions for internal drainage. Construction records are limited, other than as-built drawings and brief notes from resource consent compliance field inspections.

2 Walkover visual inspection

The dam has been inspected in early 2021 separately by two senior specialist dam engineers, David Bouma and Dewi Knapstein.

3 Geotechnical investigation

A geotechnical investigation has been completed to assess the geotechnical characteristics of the existing embankment and the dam foundations. The investigations and results are described in the Geotechnical Factual Report (Tonkin & Taylor Ltd (2), July 2021).

4 Hydrology and hydraulic assessment

A comprehensive hydrological and hydraulic assessment has been completed to assess the potential peak flood flows at the dam site in the present day, allowing for changes that have occurred in the catchment, additional data collected, and advances in hydrological and hydraulic practice since the time of the original design. Future scenarios allowing for urban growth and infill development in the catchment, and climate change, have also been considered. The key results from this assessment are described in (Tonkin & Taylor Ltd (3), July 2021).

The results of these investigations and analyses have highlighted several dam safety deficiencies when the existing dam is compared with modern dam safety and engineering practice (i.e., the DSG) as summarised in the following section.

4 Dam safety deficiencies and recommendations

The DSG categorises dam safety issues and deficiencies into four categories as defined in Table 4.1. Table 4.2 summarises the issues and deficiencies identified at the existing dam and provides recommendations on how to address these.

RLC as the dam owner, has the responsibility for ensuring the dam is safe. Given the dam has been assessed as a High PIC, the confirmed dam safety deficiencies identified in Table 4.2 below need to be addressed with urgency.

Table 4.1: Dam safety issue and deficiency categories

Term	Definition
Physical Infrastructure Issue (PII)	Equipment, access, instrumentation, communications, or maintenance is insufficient to verify satisfactory dam performance.
Potential Dam Safety Deficiency (PDSD)	Performance requirements may not be met (unknowns exist, and further investigation and/or assessment is required).
Confirmed Dam Safety Deficiency (CDSD)	Adverse performance has already been observed or will definitely come to pass under appropriate loading conditions.
Non-conformance (NC)	Dam safety management system processes and procedures have not been followed or established dam safety practices have not been implemented.

Table 4.2: Dam safety issues and associated recommendations for Linton Park East dam

Reference	Description of issue or deficiency	Recommendation to address issue or deficiency
CDSD-1	<i>Inadequate dam embankment and foundation strength and stability.</i> Recent geotechnical investigations have shown that the existing dam embankment has not been constructed well. The dam fill is described as having a “high variability in strength and consistency throughout unit”. The fill material is of variable consistency and includes some refuse and unsuitable fill. The original topsoil was not removed prior to placing the dam fill.	Remove the existing dam embankment, prepare foundations, and replace with properly selected and engineered dam fill embankment. Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.
CDSD-2	<i>Inadequate dam embankment seepage control.</i> The existing dam embankment has no measures to control seepage through the dam during an impoundment event. The risk of failure by internal erosion through the existing embankment or foundations is considered unacceptably high.	Remove the existing dam embankment, prepare foundations, and replace with properly selected and engineered dam fill embankment and include defensive measures to control seepage through the dam and foundations (e.g., filter compatible drainage layers). Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.
CDSD-3	<i>Inadequate seepage control along culvert.</i> The design drawings do not show any means to prevent seepage and internal erosion along the outside of the existing culvert. This is a common failure mode in earth dams.	Remove and replace existing culvert and include adequate seepage control measures in the replacement. Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.
CDSD-4	<i>Inadequate spillway capacity.</i> The original culvert and spillway design allowed for a peak inflow of 17 m ³ /s for a 100-year ARI flood. Given the PIC rating for the dam is assessed as High, the combined spillways should be able to safely pass at least a 10,000-year ARI flood, and should provide	Replace the existing dam and spillway with one that meets spillway capacity and freeboard as recommended in the DSG for High PIC detention dams. Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.

Reference	Description of issue or deficiency	Recommendation to address issue or deficiency
	for future development in the catchment, and increased flows expected because of climate change. The required spillway capacity has been assessed as 260 m ³ /s (see (Tonkin & Taylor Ltd (3), July 2021).	
CDS-5	<i>Inadequate and variable freeboard.</i> The crest of the existing dam is variable in height, and not high enough to provide an appropriate level of freeboard during the design flood. Current modelling (see (Tonkin & Taylor Ltd (3), July 2021)) indicates that the dam crest is likely to overtop in flood events larger than a 10-year ARI flood (present day climate, existing development), and <i>may</i> fail in this event. It is judged <i>likely</i> to fail in a 20-year ARI flood and above.	Replace the existing dam and spillway with one that meets spillway capacity and freeboard as recommended in the DSG for High PIC detention dams. Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.
CDS-6	<i>Existing auxiliary spillway not sufficiently robust.</i> The auxiliary spillway on the existing dam consists of a lowered section of dam embankment reinforced with soil control mat. This arrangement is not considered sufficiently robust to withstand erosion of the underlying dam embankment during a spill event. The soil control mat is exposed and damaged in places.	Replace the existing dam and spillway with one that meets spillway capacity and freeboard as recommended in the DSG for High PIC detention dams. Section 5 of (Tonkin & Taylor Ltd (3), July 2021) describes an acceptable solution.
PII-1	<i>Inadequate performance monitoring instrumentation.</i> The existing dam has no instrumentation that enables the performance of the dam to be monitored.	Include instrumentation in the replacement dam that enables monitoring of embankment settlement, pore water pressure in the embankment, water level in the reservoir, flows from toe drains. Refer to Sections 5.12 and 6 of (Tonkin & Taylor Ltd (3), July 2021) for further guidance.
NC-1	<i>Inadequate dam safety management.</i> Apart from general asset management procedures for stormwater assets, there is no system in place that we are aware of for dam safety management.	Develop and initiate a Dam Safety Management System in accordance with Module 5 of the DSG. This should include the elements listed in Table 4.1 of Module 5 of the DSG. Refer to Section 6 of (Tonkin & Taylor Ltd (3), July 2021) for further guidance.

5 BOPRC Dangerous Dam Policy

The Bay of Plenty Regional Council (BOPRC) has a Dangerous Dams Policy (DDP) that was adopted on 13 February 2007. The Policy refers to the Building Act 2004 definition of a dangerous dam which is duplicated as Figure 5.1 below.

153 Meaning of dangerous dam

A dam is **dangerous** for the purposes of this Act if the dam—

- (a) is a high potential impact dam or a medium potential impact dam; and
- (b) is likely to fail—
 - (i) in the ordinary course of events; or
 - (ii) in a moderate earthquake (as defined in the regulations); or
 - (iii) in a moderate flood (as defined in the regulations).
- (c) *[Repealed]*

Section 153(b): replaced, on 15 March 2008, by section 31(1) of the Building Amendment Act 2008 (2008 No 4).

Section 153(c): repealed, on 15 March 2008, by section 31(2) of the Building Amendment Act 2008 (2008 No 4).

Figure 5.1: Building Act 2004 definition of a dangerous dam

Clause 153 (b)(iii) refers to a moderate flood as defined in the regulations. The Dam Safety Regulations were repealed in 2008 and are still in the process of being replaced. However, the spillway capacity assessment described above indicates that this dam is likely to fail in a flood event with an ARI of approximately 20 years, which is expected to be well within a reasonable definition of a moderate flood.

Section 153B of the Building Act requires owners of dangerous dams to notify the regional authority.

Section 154 of the Building Act gives the regional authority the power to give written notice requiring work to be carried out on the dam within a time stated in the notice to reduce or remove the danger.

The DDP requires owners of dangerous dams to reduce or remove the danger posed by their dam.

In this case, because the purpose of the dam is to reduce flood risk to downstream properties, removing and not replacing the dam would increase flood risk to downstream properties in some circumstances i.e., in floods less than 20-year ARI.

It is therefore clear that the dam must be repaired to make it safe, and this work should be done as soon as practicable.

The accepted industry practice for design standards for this repair work is the NZSOLD DSG.

6 Proposed remedial works

Given the deficiencies associated with the existing dam, it is proposed to remediate the dam on the same site. The remediation will essentially involve removing the existing dam and replacing it with one that meets current recommended practice for engineering and dam safety. The proposed remediation also includes provision for peak flows to increase over the next 100 years due to intensification in the catchment, and due to expected increases in rainfall intensities associated with climate change.

The primary objectives of the remedial works are:

- For the completed dam to meet design guidelines recommended in the DSG;
- No worsening of present-day performance in terms of conventional flood risk to downstream property in events from the 2-year ARI up to the 100-year ARI;
- No worsening of flooding of upstream private property in the 100-year ARI, present day climate, existing development, compared with the existing dam arrangement;

- Increase spillway capacity to safely pass an Inflow Design Flood (IDF) in line with accepted industry practice. The IDF will be between the 10,000-year ARI event and the Probable Maximum Flood (PMF); and
- Provide as much attenuation as possible subject to the constraints above.

The proposed works will be undertaken under the emergency works provisions of the Resource Management Act (Section 330). A Building Consent will be obtained prior to starting the remediation work. Further details of regulatory compliance are described in Section 7.

The layout of the proposed works is shown in Figure 6.1.

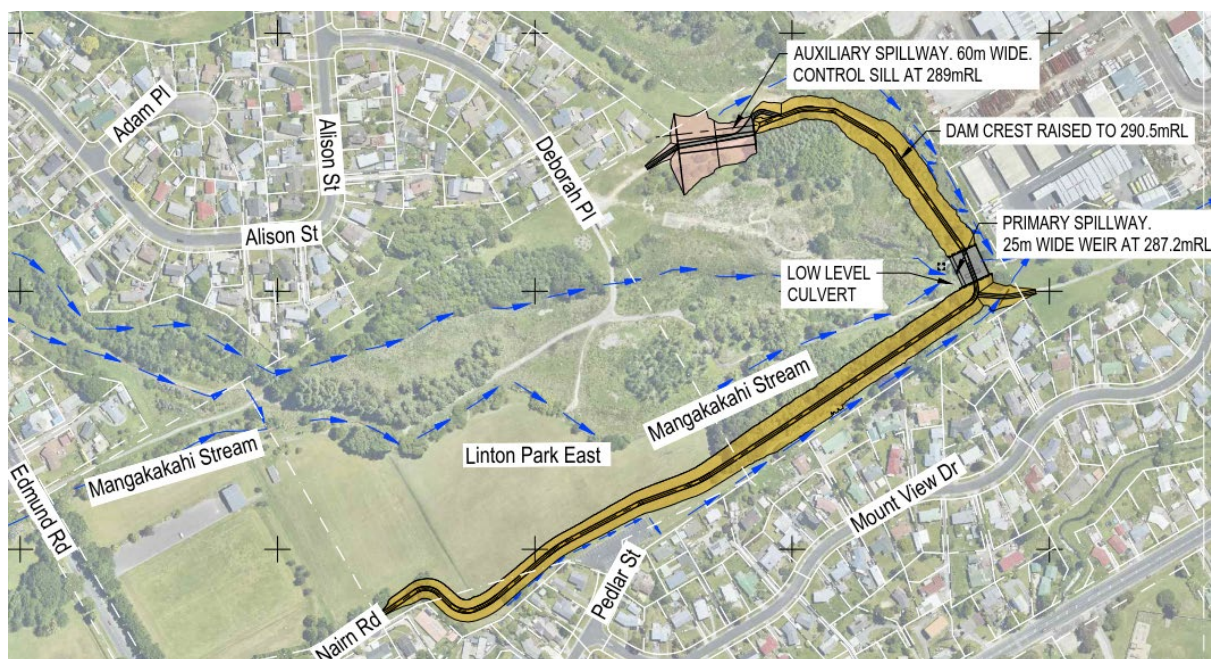


Figure 6.1: Proposed remedial works layout

Table 6.1: Remediated dam parameters

Parameter	Preliminary Design (to be confirmed during Detailed Design)
Crest level	290.5 mRL for water impoundment, with gravel footpath above this to 290.7 mRL
Crest width	3.00 m at design level for water impoundment Width of gravel footpath on crest < 3.00 m
Storage volume at dam crest	435,200 m ³ at 290.5 mRL
Maximum height (dam crest to downstream toe)	5.6 m
Embankment side slopes	1V:3H
Primary spillway	25 m long concrete weir at 287.2 mRL with 2.25 m square orifice through the weir with invert level of 284.55 mRL. Vertical side walls.
Storage volume at primary spillway crest	13,300 m ³ at 287.2 mRL
Auxiliary spillway crest level	289.0 mRL
Auxiliary spillway crest length	Reinforced grass spillway cut into natural ground around left abutment. 60 m base width, and 1V:3H side (cut) slopes

Parameter	Preliminary Design (to be confirmed during Detailed Design)
Storage volume at auxiliary spillway crest	161,400 m ³ at 289.0 mRL
IDF	Between 10,000-yr ARI and Probable Maximum Flood (PMF). For the purposes of the preliminary design, a 260 m ³ /s spillway capacity has been allowed for, corresponding to a 1-hour duration PMF inflow of 340 m ³ /s and stored ponding volume of 338,400 m ³
Total crest length	815 m

7 Regulatory compliance

7.1 Resource Management Act

The existing dam has a resource consent “to place and operate a flood detention dam on the Mangakakahi Stream” (Consent No. 05 0861).

Given that the dam has significant dam safety deficiencies (as described in Section 4) and is expected to meet the Building Act definition of a Dangerous Dam, the proposed remedial works are considered to be urgent, and will be undertaken under Section 330 (s330) of the Resource Management Act “Emergency works and power to take preventive or remedial action”.

RLC as the dam owner, will be able to invoke the s330 emergency provisions to proceed with remediation of the Linton Park East dam this coming construction season (2021-2022).

To invoke s330 emergency provisions, there must be an emergency that needs to be remediated. In this instance, the emergency is related to potential dam failure during a flood event, and then loss of flood protection after it has failed:

- 1 The dam does not meet acceptable engineering practice and is considered likely to fail in flood events greater than a 20-year ARI. Failure of the dam during a flood event would cause a sudden increase in flood level downstream that would endanger people, property, and the environment.
- 2 Once the dam has failed, it will no longer provide its intended function of reducing flood risk to downstream properties and people. Therefore, any large flood event following a dam failure event could also be an emergency situation.

To address the dam safety deficiencies described in Section 4, it is necessary to rebuild a dam to modern design standards to remove the risk of failure, and to maintain flood protection to downstream properties and people.

Even though the remedial work will proceed in the 2021-2022 construction season, a retrospective resource consent process will be required.

It is also important to note that in very large flood events, greater than the 100-year ARI (present-day climate, Existing Development), upstream ponding may potentially affect properties that were not previously affected. Therefore, a resource consent is likely to be required for on-going adverse effects on these properties (and potentially the reserve if ponding times/areas are significant and impact the usability of the reserve and potentially for the loss of any wetland area). This consent application needs to be lodged 20 working days after the notice of the works.

Further information about consenting requirements is described in (Tonkin & Taylor Ltd (4), July 2021).

7.2 Building Act compliance

When the proposed remedial work is completed, the Linton Park East detention dam will meet the Building Act definition of a Large Dam. The works will therefore require a Building Consent to be applied for and issued prior to start of construction works.

The detailed design process will follow the preliminary design (Tonkin & Taylor Ltd (3), July 2021), and will provide suitable detailed drawings, specifications, and design report to support a building consent application.

It is noted that while dams that are below the threshold for a Large Dam, such as the existing Linton Park East dam, are exempt from the need to obtain a Building Consent, they still need to comply with the Building Code¹.

7.3 Building Code compliance

It is expected that the DSG will be cited as an Alternative Solution to demonstrate compliance of the design with the Building Code in the Building Consent application.

The technical specifications and the building consent will describe certain inspections and quality assurance tests and processes that will be required during construction. These are needed to demonstrate that the works have been constructed in accordance with the building consent (and therefore with the Building Code) so that a Code of Compliance Certificate can be issued to complete the building consent process.

7.4 Proposed dam safety regulations

New regulations to protect people, property and the environment from potential dam failures are in development: <https://www.building.govt.nz/about-building-performance/all-news-and-updates/strengthening-the-safety-and-resilience-of-aotearoa-large-dams/>

The regulations will outline a system for identifying what dams are included in the regime, classifying a dam's potential impact of failure, and prescribing the required contents of a Dam Safety Assurance Programme to promote regular monitoring and surveillance practices for the safe operation of dams.

The finer details of the regulations are currently in development, and will be based on the internationally reviewed guidelines, the DSG, and further informed by the feedback from MBIE's 2019 public consultation on dam safety.

The new regulations will apply to any dams that are:

- a 4 metres or higher with a volume of 20,000 m³ (8 Olympic-sized swimming pools) or greater, or
- b 1 metre or higher with a volume of 40,000 m³ (16 Olympic-sized swimming pools) or greater.

Details of the regulations are expected to be approved by Cabinet later this year, then there will be a two-year lead in time before they come into force.

The existing Linton Park East dam is close to the applicability threshold (b) above. When the proposed remedial work is completed, the Linton Park East dam will be captured by the thresholds above.

¹ <https://www.building.govt.nz/projects-and-consents/planning-a-successful-build/scope-and-design/check-if-you-need-consents/building-work-that-doesnt-need-a-building-consent/technical-requirements-for-exempt-building-work/11-pools-tanks-and-dams/11-2-small-dams/>

It is therefore expected that RLC will need to develop and operate a Dam Safety Assurance Programme (DSAP) for Linton Park East dam, and any other Medium or High PIC dams it may own. The recommendation in Table 4.2, to prepare a Dam Safety Management System in accordance with Module 5 of the DSG, is expected to fulfil the requirement for a DSAP for the Linton Park East dam.

8 Conclusions

The existing stormwater detention dam in Linton Park East was constructed in 1998 for the purpose of flood detention to protect downstream property and infrastructure. The need for the dam to provide flood detention will remain into the future, and in fact the need for detention storage is increasing over time as the catchment upstream of the dam is developed, and climate change increases the frequency of high intensity rainfall.

The existing dam has several serious dam safety deficiencies that could potentially cause dam failure in flood events of 20-year ARI or greater. Dam failure during a flood event is likely to cause significant damage to property and the environment downstream of the dam, and may put lives at risk.

The existing dam meets the definition in the Building Act of a Dangerous Dam.

The BOPRC Dangerous Dam Policy requires that RLC as the dam owner undertakes remedial works as soon as practicable to address the dam safety deficiencies.

T+T has developed a preliminary design for remedial works to upgrade the dam to modern design standards. RLC proposes to engage a contractor to construct the remedial works over the 2021-2022 construction season.

9 Recommendations

The recommendations of this report are as follows:

- i BOPRC should be officially informed that RLC has identified that Linton Park East detention dam meets the definition of a Dangerous Dam, and that RLC intends to complete remedial works in the coming construction season, under the emergency works provisions of the RMA to address the dam safety deficiencies
- ii To address the dam safety deficiencies associated with Linton Park East flood detention dam, the remedial works as proposed in (Tonkin & Taylor Ltd (3), July 2021), as may be modified in the detailed design process, should be constructed in the upcoming construction season.
- iii To achieve construction work in the coming season, RLC and their consultant team should proceed with detailed design immediately.
- iv In order to develop a design that can be built as quickly as possible, and to have a contractor available to start work as soon as possible, RLC should engage a contractor experienced with dam construction in an Early Contractor Involvement (ECI) contract to work alongside the designers and to prepare for an early start.
- v The detailed design should be completed as soon as possible to enable an application for building consent for the works to be submitted to Waikato Regional Council (WRC). WRC should be warned that it is essential that this application is processed as quickly as possible.
- vi Preparation for resource consent applications for the modified dam should begin in parallel with the detailed design process.

10 References

- New Zealand Society on Large Dams (NZSOLD). (2015). *New Zealand dam safety guidelines*.
- Tonkin & Taylor Ltd (1). (in Preparation). *Linton Park East - Dambreak and PIC assessment report*. Prepared by Tonkin & Taylor Ltd for Rotorua Lakes Council. T+T Ref 1010988.3000.
- Tonkin & Taylor Ltd (2). (July 2021). *Rotorua Flood Detention - Geotechnical factual report - Linton Park East*. Prepared by Tonkin & Taylor Ltd for Rotorua Lakes Council. T+T Ref 1010988.3000.v1.
- Tonkin & Taylor Ltd (3). (July 2021). *Linton Park East Flood Detention Pond - Preliminary Design Report*. Prepared by Tonkin & Taylor Ltd for Rotorua Lakes Council. T+T ref 1010988.3000.v1.
- Tonkin & Taylor Ltd (4). (July 2021). *RLC Stormwater Detention Ponds Consenting Strategy*. Prepared by Tonkin & Taylor Ltd for Rotorua Lakes Council. T+T Ref 1010988.2000.v2.

11 Applicability

This report has been prepared for the exclusive use of our client Rotorua Lakes Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as part of an application for resource consent and that Bay of Plenty Regional Council as the consenting authority will use this report for the purpose of assessing that application.

Tonkin & Taylor Ltd


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