

Manawatū District Council
Pukepuke Lagoon Update for
Department of Conservation
28 August 2024



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1. Executive Summary

Manawatū District Council have reviewed available data collected by Horizons, Fish and game and Manawatū District Council to collate the information required under the Pukepuke Lagoon Concession (currently under suspension). With the exception of correspondence relating to eel numbers all of the information required by the concession is contained within this report.

- There has been no vegetation clearance within the inlet and outlet drain for at least six years.
- Water levels within the lagoon fluctuate in accordance with the seasons. Historically these levels fluctuated between 4,336mm and 5,254mm (918mm) above sea level. In 2018 the water levels appear to be artificially raised so that the lagoon now fluctuates between 5784mm and 6667mm (883mm).
- The hydraulic nature of Pukepuke Lagoon has changed as a result of increasing the minimum water level by 1,448mm. This has significantly increased the risk of flooding adjoining land and forces water to backup within the drainage network
- The extent of the Dune Lake has fluctuated over years but is currently reducing at a rate of 0.2ha a year under the current management regime.
- Raupo is the dominant vegetation type
- Long term aspirations for the site will determine if ongoing mechanical manipulation is required or the natural vegetation succession is allowed to occur.
- Long term trends indicate black swan and shovler numbers are declining.
- Inlet and outlet channels need to be reinstated to provide immediate relief to flood risk.
- Based on the LAWA summary the water quality within Pukepuke Lagoon is currently considered very poor. This rating is due to elevated nitrogen and phosphorous concentrations.
- Based on the LAWA summary the Ecological condition of Pukepuke Lagoon is considered High

Additional information relating to Pukepuke Lagoon can be found within the following reports:

- Geomorphological assessment and Management Considerations for Pukepuke Lagoon Natural Heritage Restoration Project – A report Prepared for the Department of Conservation (Dr Roger D Shand 2017)
- Natural Heritage Plan for Pukepuke Lagoon, Manawatu, Wildlands Salt L et al 2018

2. Pukepuke Lagoon Description

2.2 Site Characteristics

In 2018 the wildlands report estimated the dune lake within Pukepuke Lagoon as being approximately 500 metres long and 300m wide with an area of approximately 15ha (See Figure 1 for details). The extent of the dune lake is now approximately 13ha in size. With a balance area of approximately 56ha predominantly covered in Raupo. Anecdotal evidence suggests that the Raupo has significantly increased in recent years under the current management regime.

Water balance modelling was calibrated using the Representative Basin study data (1969 to 1983) and found that 2.1 % of water entered the lake via direct rainfall interception, 9.1% by quickflow/surface runoff (via the drainage system) and 88.8% via baseflow. Baseflow represents a combination of direct local groundwater seepage and stream flow. The effects of the drainage system under non quick flow conditions have not been assessed (Dr Roger D Shand 2017).

Pukepuke surface water level is (manually) controlled by a “block structure” at the outlet drain weir for the purpose of minimising rapid change and maintain the fluctuation to about 0.1 m during the breeding season. Water level data outlined in section 5 shows a seasonal range of about 1000 mm, reflecting high stages in winter due to high inflow and low stages in summer due to zero inflow and surface evaporation (Mark-Brown 1978). About once per decade (on average) the lake actually dries out

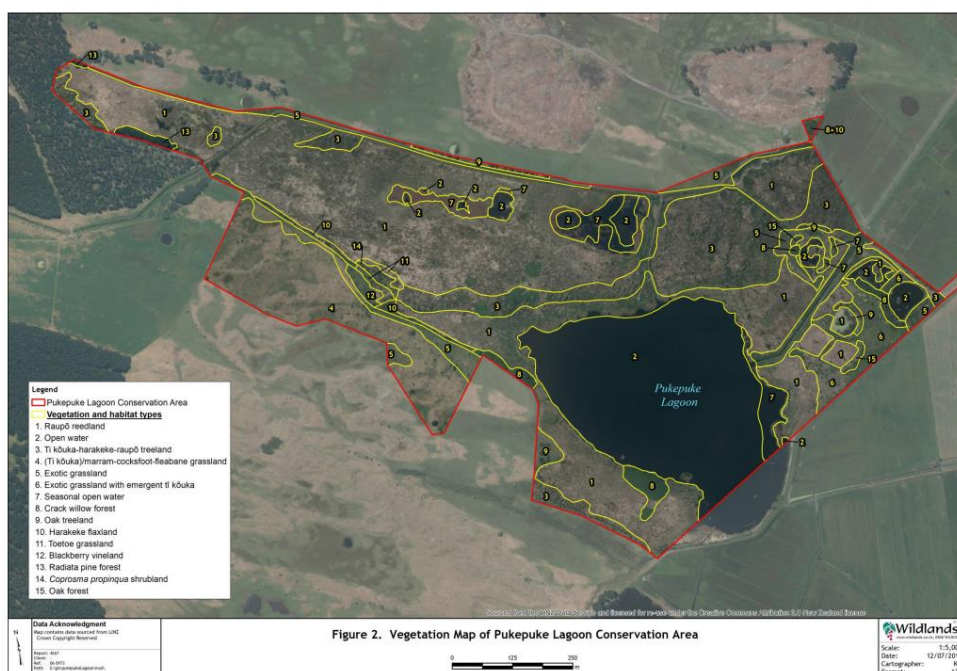


Figure 1: Pukepuke Lagoon Vegetation and Habitat (Wildlands)

With the exception of the increased extent of Raupō the vegetation survey by (Salt L. et al, 2018) is still considered accurate. As highlighted by (Dr Roger D Shand 2017) the extent of Raupō within Pukepuke Lagoon has increased and decreased over time due to the adopted management at the time (See Figure 2 for details). With the current regime having limited mechanical intervention and zero use of chemicals the size of the Dune Lake is steadily decreasing in size.

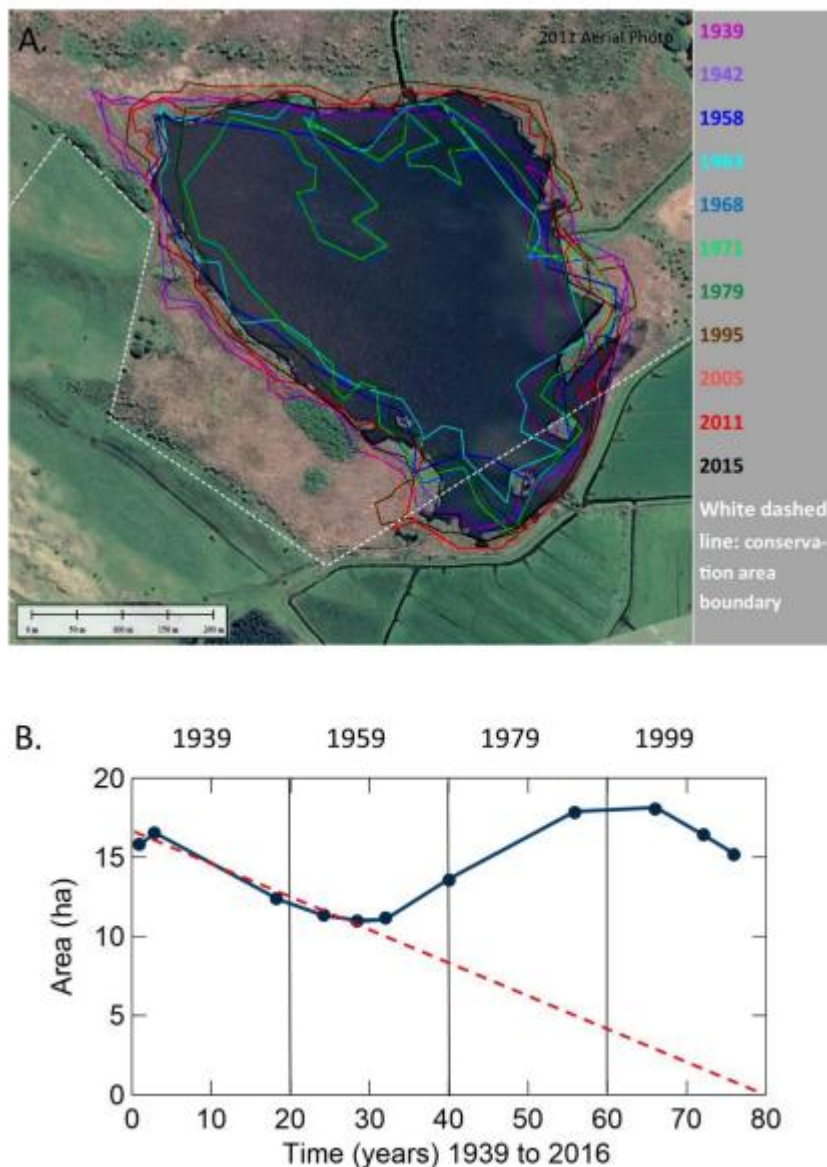


Figure 2: Water surface shoreline for Pukepuke Lagoon over time. Dashed red line is the linear regression model for 1938 to 1968 data points extrapolated to 2017 (Dr Roger D Shand 2017).

These surface area of the dune lake fluctuates between a minimum of 10.9 ha in 1968 to a maximum of 18.2 ha in 2005 (Dr Roger D Shand 2017). Notwithstanding seasonal hydrological variation (Noise) the surface area of the dune lake reduced through to the early 1970s, then increasing through to the 1990 and more recently decreasing to 15.2 ha in 2015. This pattern

aligns with the adopted Wildlife Service's raupo control programme at the time (*Dr Roger D Shand 2017*). Under the current management regime the extent of the dune lake is reducing at approximately 0.2ha/year and is expected to surpass the minimum area of 1968 prior to 2034. This rate of decline will continue until 2070 when the extent of the Dune Lake is expected to be negligible. A clear decision around the aspiration for the area is required before a decision is made to intervene to retain the dune lake or allow the area to follow a natural successional pathway into a semi-swamp forest, perhaps dominated by kahikatea and pukatea like the Omarupapaku Reserve near Foxton (Esler and Greenwood, 1968; McFadgen, 1972). If the later is adopted, selective planting could accelerate this process if desired.

The shape and extent of the lagoon has changed over time with the Lagoon historically stretching further north of its current location. Extensive changes to local drainage, changes in land use and the dynamic nature of coastal strips has resulted in the Pukepuke Lagoon reducing to its current size and location (See Figure 2 and 3 for details).

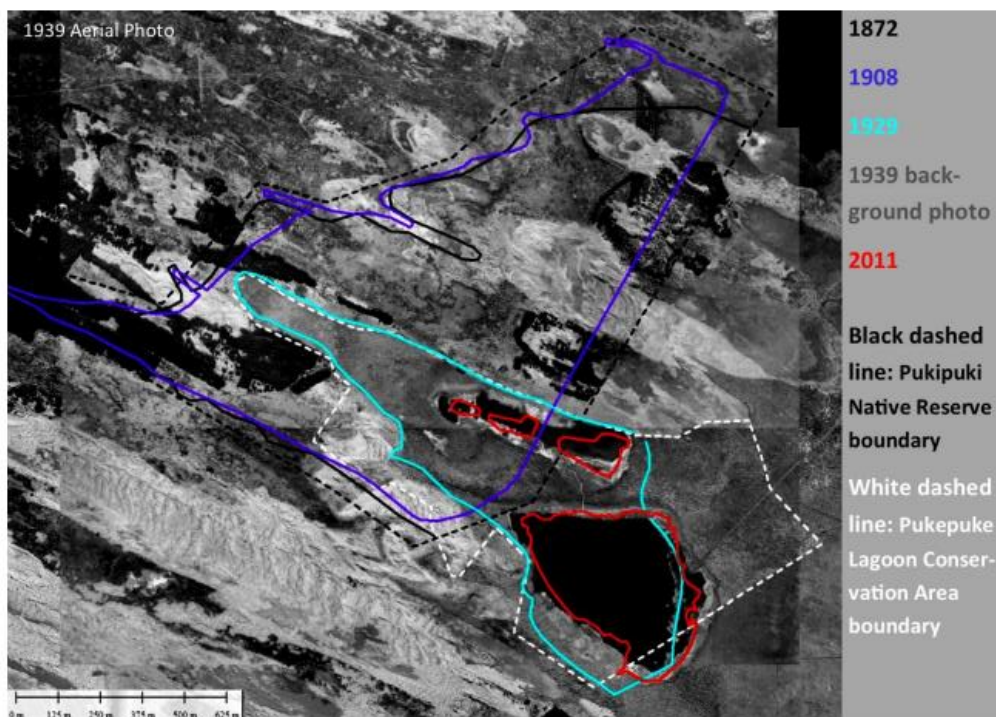


Figure 3: Changes in extent of Pukepuke Lagoon over time

The current key features of the Pukepuke Lagoon consist of dune lake (13ha), Inlet channel, secondary drain (pumped) perimeter outlet, outlet weir and a bypass channel (See Figure 4 for details).

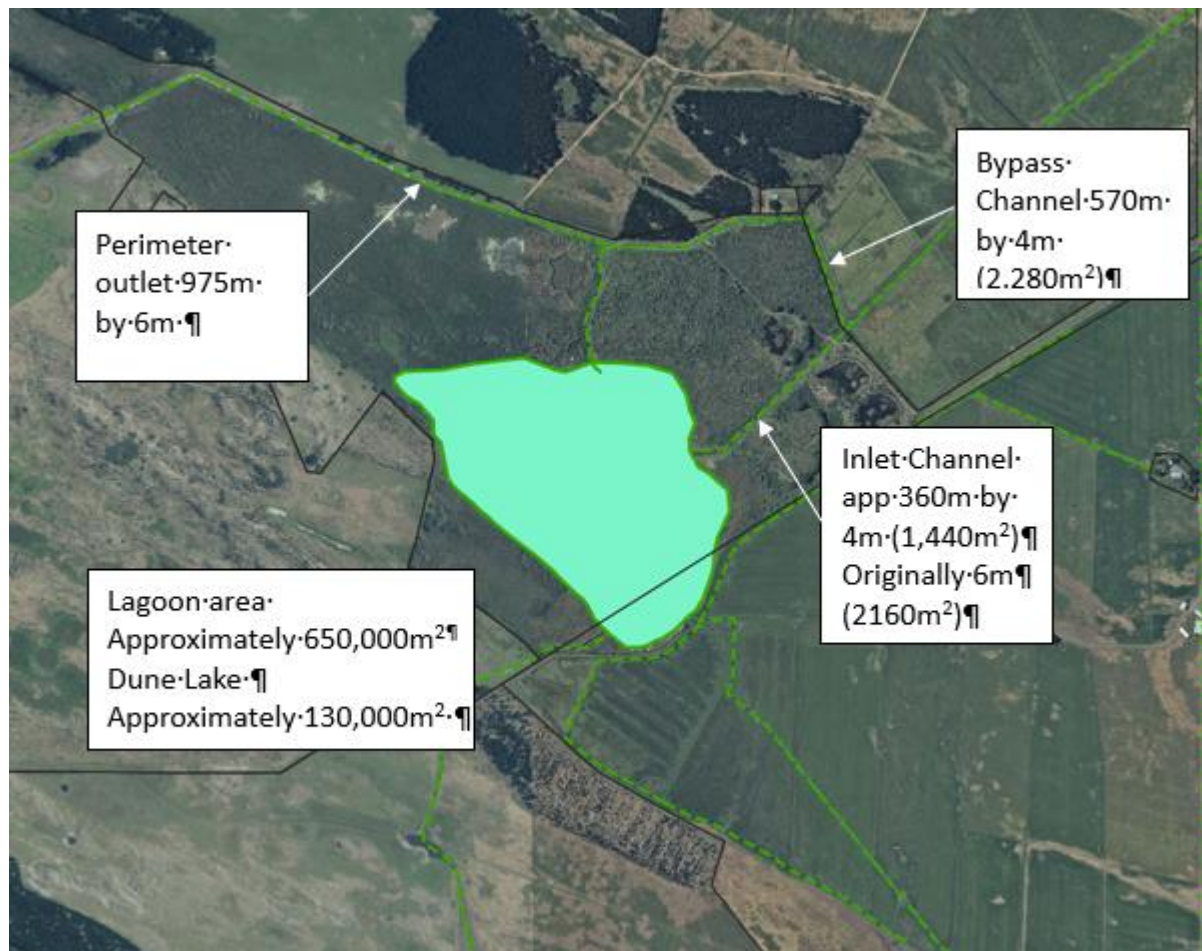


Figure 4: Key features of Pukepuke Lagoon

3. Emergency Meeting

An emergency meeting on 20 August 2024 was requested by Manawātū District Council due to significant flooding. The following representatives attended the meeting:

- Manawātū District Council representatives
- Drainage board members representatives
- Department of Conservation representatives

The meeting focused on the reduced flood carrying capacity of the Main Drain inlet due to vegetation growth. While collating this report after the meeting, it appears that the water level within the lagoon may have been artificially alleviated in 2018. These changes may have contributed to the current hydrological conditions of Pukepuke Lagoon and surrounding drainage network (see Section 5 for details).

The combination of alleviated water levels and vegetation encroaching into the Main Drain Pukepuke inlet caused water to back up within the drain and find an alternative flow path into an adjoining property. Subsequently approximately 13.4ha of land was submerged.

The rain event that caused this flooding was considered a moderate event. Therefore it is highly likely that a re-occurrence will occur if the capacity issues within the Main Drain inlet are not addressed. Alternatively the former bypass channel could be reinstated to allow high flows to bypass the Lagoon during extreme events. .

3.1 Event Summary

Over a 48 hour period (18 August 2024 and 19 August) 77.2mm of rain was recorded at the Horizons Sluggish Creek rain fall site (See Figure 5 for details). This is considered a moderate event and is expected to occur frequently throughout the year. Therefore an event of this size or larger is expected to occur in the immediate future. While Horizons don't have a rainfall site at Pukepuke Lagoon itself, anecdotal evidence suggests that similar intensities occurred at Pukepuke Lagoon with 90mm of rain being privately recorded over the same period.

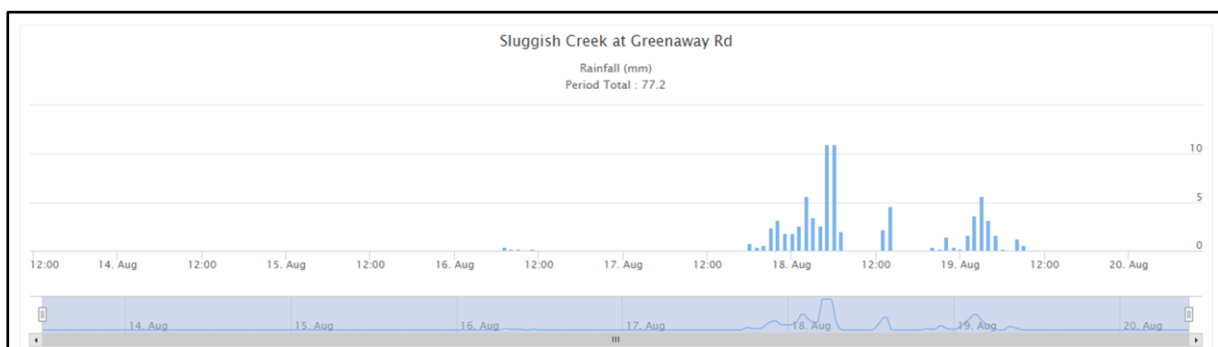


Figure 5: Horizons rainfall data from Sluggish Creek

The moderate short term storm event caused the flows in the Main Drain to exceed the capacity of the Main Drain inlet into Pukepuke Lagoon. While the inlet drain is designed to have an equivalent capacity to the Main Drain, this capacity has steadily reduced over the last six years as there has been no vegetation control. As a result vegetation has effectively created a natural barrier / dam within the Main Drain Pukepuke Lagoon inlet. Once the water in the Main Drain exceeded the capacity of the inlet the excess water backed up within the drain and ultimately forced the drain to create an alternative flow path. This flow path diverted the water from the Main Drain catchment into the adjoining catchment which is situated below Pukepuke Lagoon. As this adjacent catchment does not have a natural outlet the entire volume of water needs to be pumped for it to continue on its journey to the coast.

The Main Drain catchment is almost ten times the size of the adjoining catchment (See Figure 6 for details). Subsequently the pump for the smaller catchment is not designed to pump the combined flows of both catchments. As a result the additional volume of water has caused approximately 13.4 hectares of land to be submerged. Of this approximately 8ha is on Pamu (Landcorp Farming Limited) and 5.4ha is on Percy Pastures land. As these properties are the

lowest properties and are situated below Pukepuke Lagoon with no natural outlet, these properties are disproportionately effected when water is prevented from entering or leaving the Pukepuke Lagoon (see Figure 7 and 8 for details).

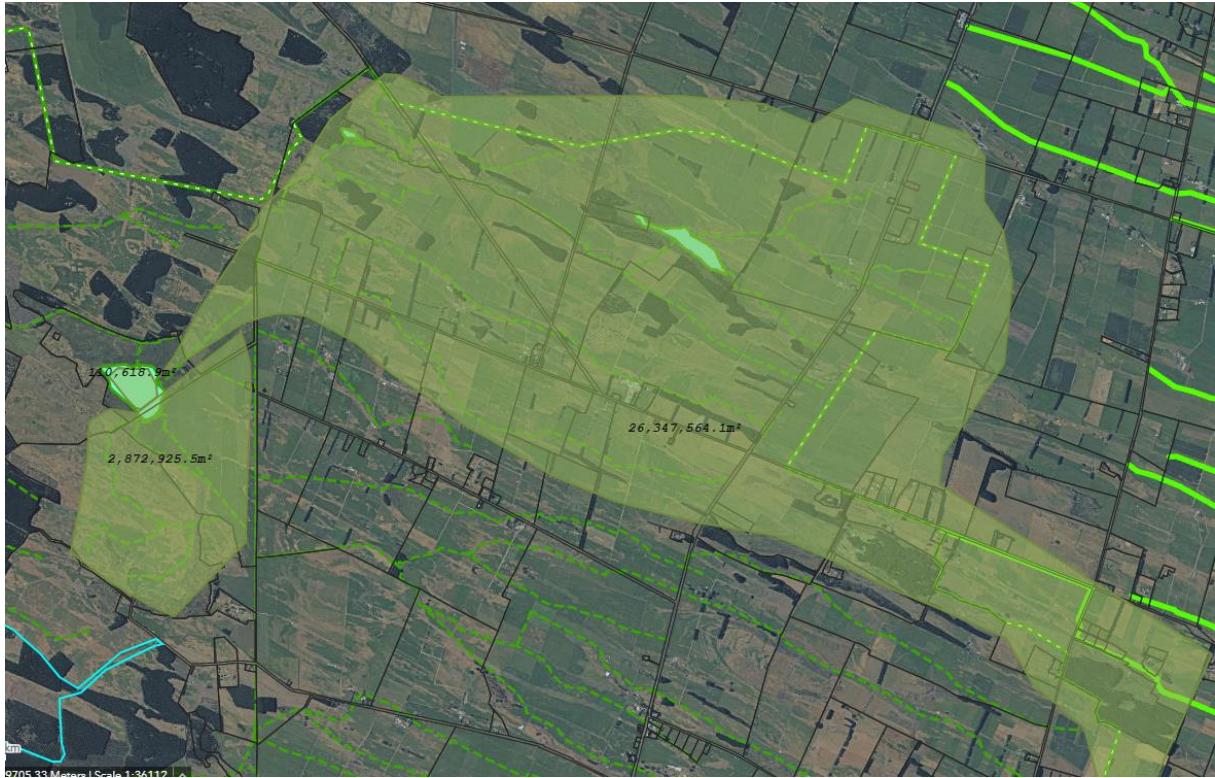


Figure 6: Drainage board catchments for the Pukepuke Lagoon



Figure 7: 19 August 2024 flooding event



Figure 8: Previous winter (2023)

Main Drain Inlet

The Main Drain is approximately 6 m wide within the section that is on private property. Once this drain enters the Conservation Land, the drain is restricted with an average width of 4m but sections are almost completely blocked. This bottleneck within the drain has been caused as there has been no active vegetation removal over the last six years. This has allowed aquatic

plants and raupo to encroach into the drain. In order to remove this constriction the inlet drain needs to be reinstated to its original width of six metres. This section of inlet drain that needs to be reinstated is approximately 335 metres long (See Figure 9 for details). Majority of the work is required in the first 180m of this inlet.

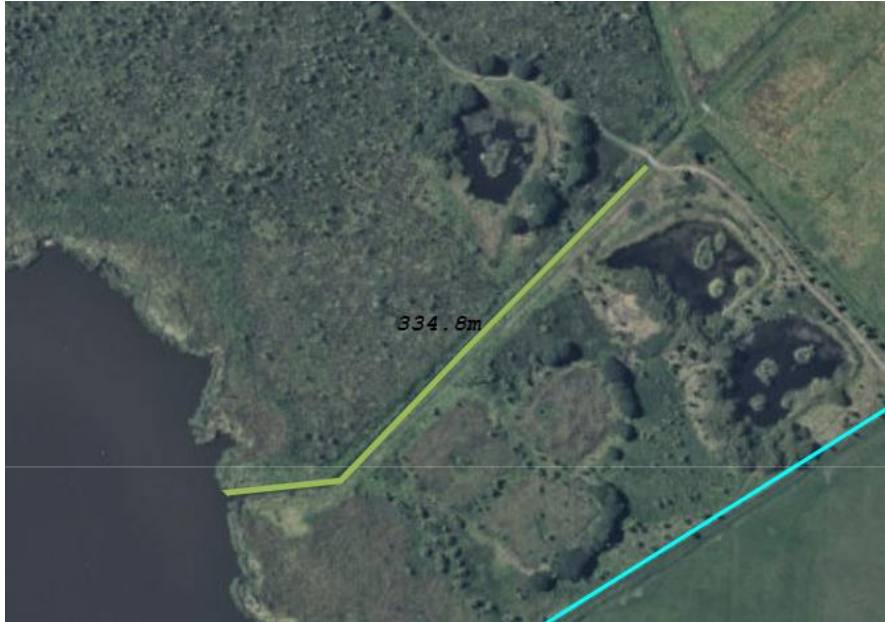


Figure 9: Main Drain Inlet

Perimeter Drain Outlet

The water level within Pukepuke Lagoon is controlled by the Pukepuke Lagoon outlet weir. However, the vegetation restrict flow further during extreme events. This causes the water level within the lagoon to temporarily rise. As there is limited freeboard this can in turn cause water to spill back out of the lagoon onto the adjoining properties. Subsequently it is equally important that the capacity of the outlet drain is also maintained (See Figure 10 and 11 for details).



Figure 10: Pukepuke Lagoon perimeter drain

Vegetation has also encroached on the perimeter drain with the average width being approximately four metres. This needs to be increased to six metres in accordance with the concession. While the average width of the perimeter drain is approximately four metres there are sections of this drain where vegetation has blocked the drain in its entirety (See Figure 11 for details).



Figure 11: Perimeter Drain

4. Site Visits

Since obtaining an access permit on 18 June 2024, Council have undertaken two site visits. These site visits occurred on 19 June 2024 and 22 July 2024 with the third site visit due at the start of September 2024. Photos from these visits have been included below.

Raupo is the dominant vegetation with it covering approximately 80% of the site. Based on anecdotal evidence it has been steadily increases over the last six years. Reports from Massey University indicate that the extent of Raupo is increasing at approximately 0.2ha per year. This increase is the main reason why the Main Drain inlet and outer perimeter has reduced capacity.



Figure 12: Predominant vegetation - Raupo

In the background of the left image in Figure 13 raupo can be seen partly blocking the Main Drain Inlet. Based on satellite imagery these restraints are common within the first 180 metres of the inlet drain. During high flows these restraints create a barrier that forces water to back up within the drain. In comparison the Main Drain within private property has retained its design capacity (see Figure 13 for details on the right). As the vegetation within the drain is periodically submerged it is unlikely to provide a suitable nesting habitat. Notwithstanding this a survey of the entire length of the Main Drain inlet is required before any vegetation removal occurs.



Figure 13: Main Drain inlet – Pukepuke Lagoon versus private section of Main Drain

There are several areas outside the main dune lake where raupo has been removed to form smaller areas of open water. These areas are evident in Figure 1 at the start of the report and figure 14 below.



Figure 14: Artificially created open water areas within Raupo

Raupo can be seen around the entire perimeter of Pukepuke Lagoon dune lake (See Figure 15 for details).



Figure 15: Raupo is reducing the extent of the main open water section of the Lagoon

While the outlet weir ultimately controls the water level with Pukepuke Lagoon the vegetation within the outlet holds up water during high flow events. This results in the lagoon level fluctuating by approximately 1000mm over the year. As can be seen from Figure 16, sections of the Pukepuke Lagoon outlet drain are restricted due to vegetation.



Figure 16: Vegetative restrictions within Outlet of the Lagoon and Perimeter Drain

At the time of the site visits with the current flows the fish passage was considered that aquatic vertebrates could migrate from the coast to Pukepuke Lagoon with no physical barriers within the perimeter drain observed (See Figure 17 for details). While outside the control of the concession holder the fish passage could be compromised during low flow conditions.



Figure 17: Fish Pass and section of perimeter outlet on private property

5. Water Levels

Horizons continuously measure the water level with Pukepuke Lagoon. Based on the current daily data set there is a clear seasonal fluctuation of the lake between the weir high and the maximum freeboard. This seasonal pattern was more distinct in historical data recorded prior to 2018. Something occurred in 2018 that suddenly increased the water level within Pukepuke

Lagoon (see Figure 18 for details). This increased the minimum water level from approximately 4336mm to approximately 5784mm. Given that there was a step change it appears that the outlet weir was altered in 2018 to change the minimum water level by 1,448mm. A change of this nature effects how the Pukepuke Lagoon operates hydraulically and increases the importance of maintaining inlet outlet capacity as there is limited freeboard. Notwithstanding this, the water level within the Lagoon since this change has fluctuated between 5784mm and 6667mm (883mm). As the water level post the change in 2018 increased steadily over a period of couple of months this change indicates that the Lagoon was steadily filling up rather than a step change where the levels were recalibrated where the change would have been instantaneous. More information is required to understand what caused this increase and why it was implemented.

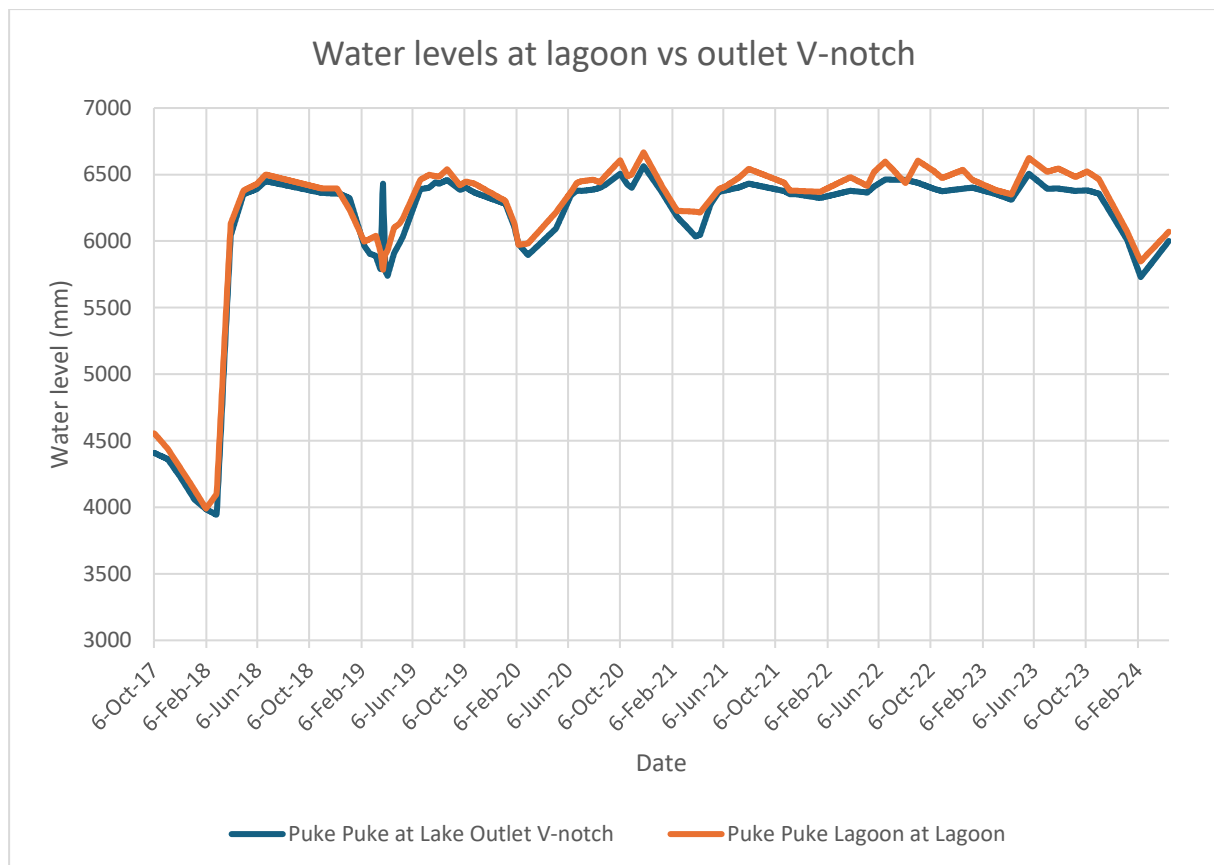


Figure 18: Daily water level records from Pukepuke Lagoon.

The historical information demonstrates that the Lagoon used to reseed down to 4336mm mark on a seasonal basis (See Figure 19 for details). Therefore the changes in 2018 permanently lifted the level of the lagoon and significantly increased the risk of flooding for surrounding land.

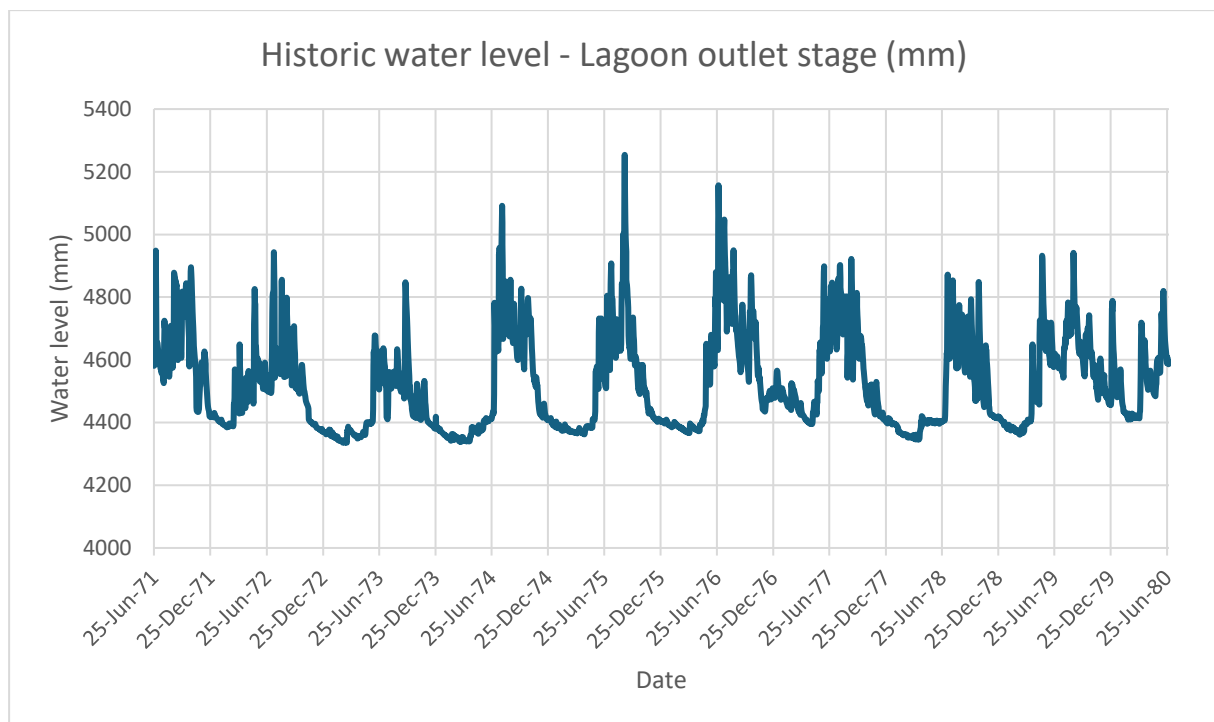


Figure 19: Historical water level records

6. Water Quality

Horizons collect data from Pukepuke Lagoon on a regular basis. Based on this data LAWA have assessed the water quality of the Lagoon as being very poor while maintaining a high ecological value (See Figure 20 for details).

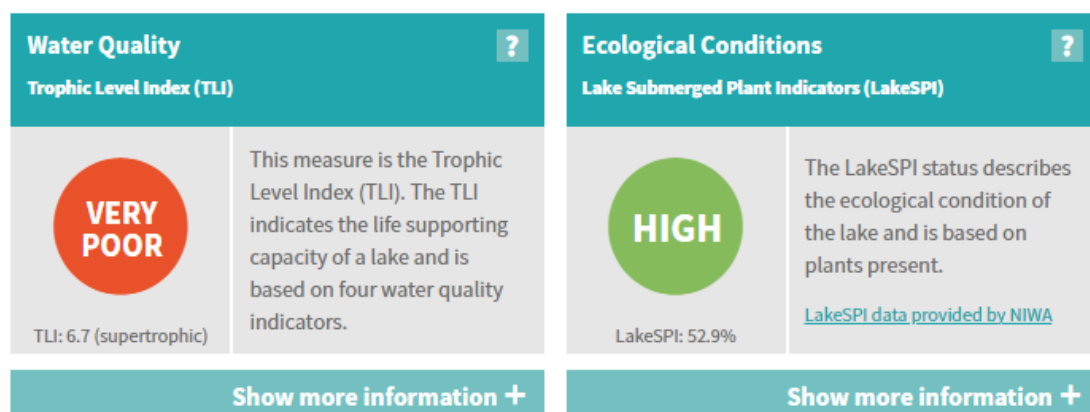


Figure 20: LAWA assessment of Pukepuke Lagoon

The poor water quality assessment is primarily due to elevated Nitrogen and phosphorous concentrations (See Figures 21 and 25 for details).

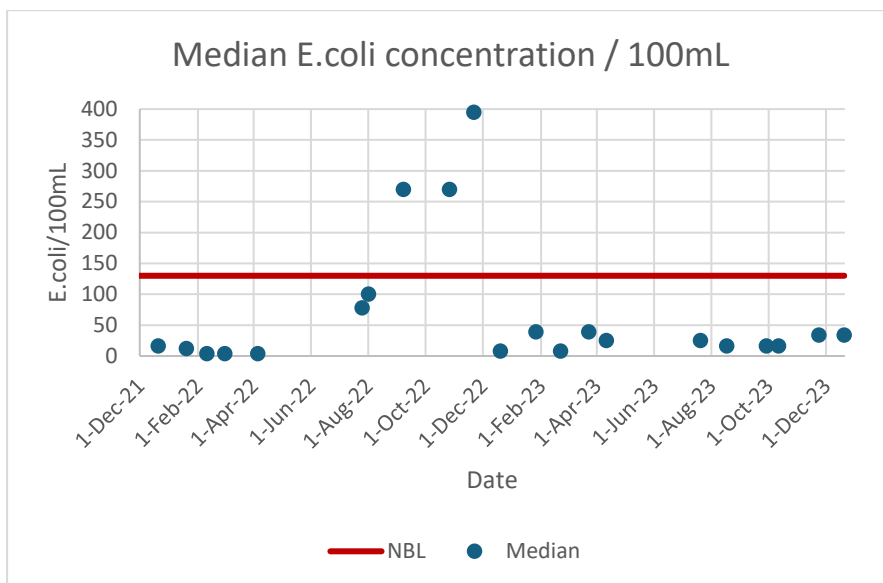


Figure 23: Median E.coli concentrations

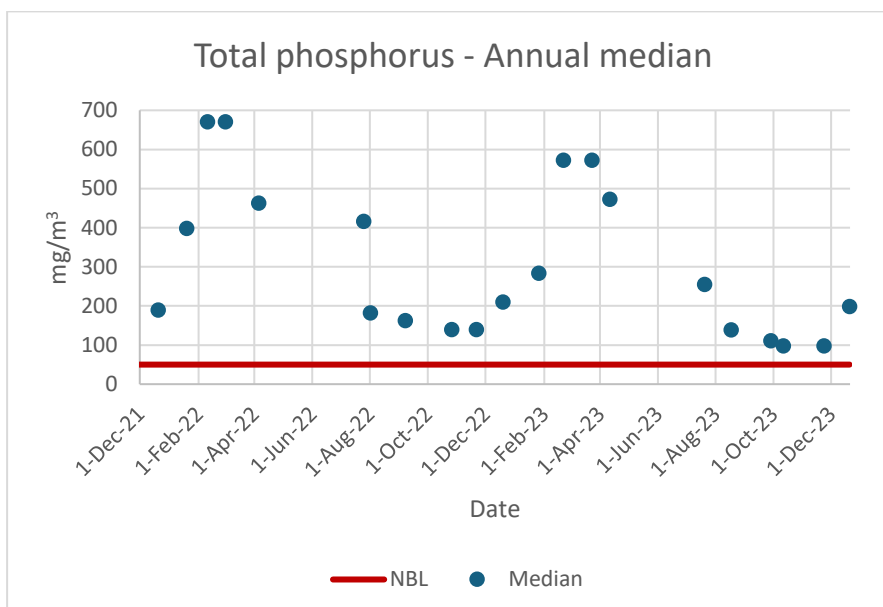


Figure 24: Median phosphorous concentrations

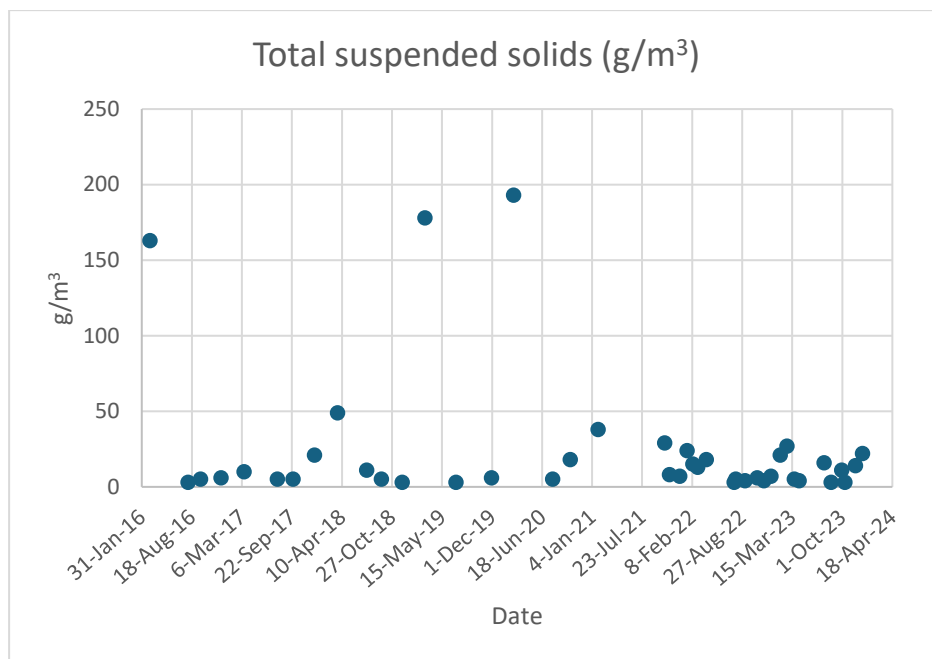


Figure 25: Total Suspended solid concentrations

7. Bird Numbers

Fish and Game have provided a record of black swan and NZ shoveller ducks observed on Pukepuke Lagoon.

During the two site visits significant numbers of black swans were observed but an actual count was not conducted.

While actual numbers of black swans are not available for the 2022,2023 and 2024 years the numbers of black swans are showing a declining trend.

Table 1: Fish and Game bird counts 2018 - 2024

2018	2019	2020	2021	2022	2023	2024
130	60	40	27			

The absence of data from 2022 onward may be because no swan were present or the site was not counted. However this data should be taken in consideration to the wider black swan population trend for the lower western North Island – see below – with large increase in swan numbers occurring in the lower North Island in the past two years.

Table 2: Lower North Island swan numbers

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1346	2643	1040	2341	1171	1246	897	1262	670	2357	2258

Swans feed on algae and weeds by plunging their long necks up to 1000mm deep. Subsequently if the lagoon has been raised by 1448mm the foraging area of the Lagoon might have significantly reduced to the edges and shallow end of the Lagoon.

Based on the Fish and Game records the NZ shoveller duck numbers observed on Pukepuke Lagoon have also got a declining trend.

Table 3: NZ Shoveller / Kuruwhengi data

NZ Shoveller/Kuruwhengi data below

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
92	363	217	0	52	320	45	77	107	16

It is unclear why the numbers of black swans and shovel ducks are declining and if it is correlated with the Lake Dune extent or if the apparent increasing the depth has impacted the extent of foraging area.

8. Proposed Flooding Mitigation

There are two options to prevent extensive flooding from occurring in moderate storm events.

Option 1: Preferred Option

- Reinstall the Main Drain Inlet drain into Pukepuke Lagoon to its original six metre width.
- Reinstall the outlet Drain to its original six metre width

Option 2: Reinstall the designed secondary bypass

- Reinstall the secondary flow path so when the Main Drain backs up it flows through the bypass and not floods neighbouring land
- Widen the perimeter drain to its original six metre width

9. Vegetation Clearance

The concession provides provisions for both chemical and mechanical vegetation clearance. However controlling vegetation through chemical methods is not widely supported. While the concession is current suspended if vegetation removal is approved it should be in general accordance with the requirements of the concession.

Schedule 3 summarises the requirements of vegetation clearance. (it is noted that this concession is currently suspended)

- (1 Jan – 31 March) previous discussions indicated that there is a preference to make changes to this
- Grantor can approve a higher frequency of clearing subject to Raupo growth , flow restrictions,
- 28 days notification required
- Weed bucket must be used for mechanical clearing
- No material is to be placed on the tracks
- Channels are not to be widened past the present width of the six metre weir.
- Channels are not be deepened during mechanical clearing

As it is proposed to remove vegetation outside the 1 January – 31 March window a detailed survey of the drains should be completed to ensure there are no nests or breeding birds in the subject areas.