PEGASUS – MANAGING A NEW LAKE IN AN URBAN ENVIRONMENT

South, S. Golder Associates (NZ) Limited

ABSTRACT

Pegasus Lake is a 14 ha manmade lake in Pegasus Town, a new residential and commercial development in Canterbury. The design objectives for the lake were to provide an aesthetically pleasing lake that was suitable as a recreation facility.

Pegasus Lake was constructed in 2009, and is fed by both stormwater and groundwater. Since its completion, Golder has monitored the water quality and visual aesthetics of the lake. Through this monitoring, Golder has noted the lake's response to: stormwater, algae growth, weed growth, microbiological contaminants, groundwater inputs, and increased urban development.

Stormwater contaminants appear to play a minor role in the lake's water quality. Algae and weed growth appear during periods of favourable meteorological and chemical conditions which in turn lead to a rapid deterioration in clarity and colour. Pegasus staff have learned to control these changes through the management of groundwater inputs, riparian margins, lake level and maintenance.

The intended recreational and aesthetic design objectives of Pegasus Lake have at times conflicted with its ecological performance, and the result is a balancing act between an engineered system and a natural ecosystem.

KEYWORDS

Water quality, lake, Pegasus Town, urban, algae, aesthetic

1 INTRODUCTION

1.1 PEGASUS TOWN

Pegasus Town is a development comprising residential, commercial and recreational facilities. The town is situated on approximately 285 ha of land to the north-east of Woodend in the Waimakariri District of North Canterbury on a greenfield site (Figure 1). The development is bordered to the west by State Highway 1, and to the east by the Pegasus Bay coastline. The area was originally farmland, with an area of dunes adjacent to the coast.

The development has included the construction of Mapleham Golf Course and numerous small lakes on the western side of the area. A commercial district is under development and future public amenities will include a school, shopping and restaurant precinct.

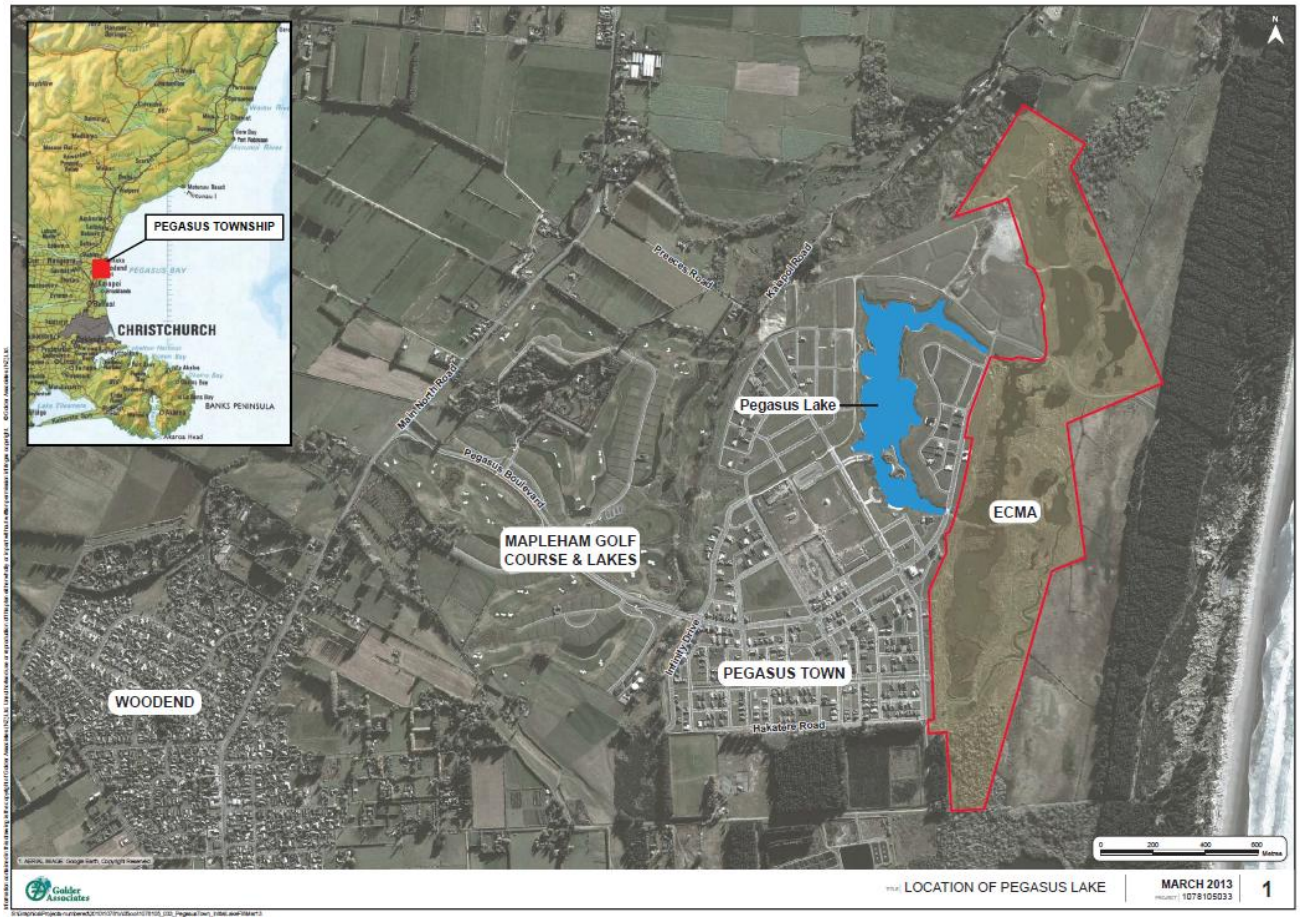


Figure 1: Location of Pegasus Lake

The site also includes a 14 ha constructed lake (Pegasus Lake), and a wetland area to the east of the site known as the Eastern Conservation Management Area (ECMA).

Pegasus Lake was constructed in 2009. As part of the development, Todd Property Pegasus Town Limited (TPPTL) obtained resource consents that authorised the taking and using of groundwater, the taking and diversion of surface water, and the damming of water. The conditions of the consents require TPPTL to undertake a range of water quality monitoring in the lake and ECMA.

1.2 PEGASUS LAKE DESIGN AND MANAGEMENT OBJECTIVES

The Lake Management Plan (Beca 2008) sets out lake uses and objectives for Pegasus Lake. Briefly, these are:

- The lake will be suitable for secondary contact recreation activities such as kayaking and boating
- The lake will be suitable for passive/casual recreation activities on the lake perimeter e.g., walking, picnicking
- Management of the visual aesthetics of the lake (clear water, minimal scum/debris, no odour or unnatural water colour)
- Management of the lake for recreation – in addition to the lake's suitability and use for secondary contact recreation, the risk of potentially toxic algal blooms is to be minimized

Alongside these explicit visual and recreational-based criteria, there were additional objectives considered during the development of the design and development of Pegasus Lake:

- Cultural objectives; recognise the inherent value of water to Tangata Whenua and potential effects on water quality

- Flood management and storage; attenuate peak stormwater flows from the development and provide flood storage

The Resource Management Act and the consenting process have ensured that these objectives are now embedded within the future evaluation framework for Pegasus Lake in the form of consent conditions. Consent conditions require the following criteria to be met in Pegasus Lake:

(a) It is suitable for the activities and uses for which the lake and its water are proposed in the Lake Management Plan to be used for; and

(b) It is generally suitable for secondary contact recreation; and

(c) It does not result in persistent seasonal stratification leading to oxygen depletion in the lake; and

(d) It does not result in toxic or nuisance algal blooms.

2 DESIGN OF PEGASUS LAKE

Pegasus Lake is around 14 ha in area and is formed in a generally north-south orientation, parallel to the nearby Pegasus Bay coastline. The lake has an island, accessed by a pedestrian bridge, with a waterfall on the island recirculating water from the lake.

Excavation of the lake intercepted groundwater, and this groundwater is its primary source of inflows. Long term average groundwater inflows were estimated at 12 L/s (Beca 2007), 50 % of which enter via Riccarton gravels underlying the lake. Groundwater enters the lake floor in a number of locations, with the 'lagoon' area one location of note.

Stormwater from the Pegasus town centre is treated via sand filters, then piped to Pegasus lake as another source of inflow. Stormwater from residences and roads is discharged directly via soakage for up to a 10-yr event. Therefore only flows in excess of 10-yr events will travel directly via overland flow into the lake or ECMA.

Two v-notch weirs control the outflow from Pegasus Lake into the ECMA. These weirs are located at the north and south ends of the lake, contributing to a southerly direction of flow through the ECMA. The weirs are adjustable, and can provide attenuation within the lake of up to 250 mm in floods, or enable outflow into the ECMA during low flows periods. From the ECMA, the water flows into the dune area, towards the Ashley River.

A number of design features of Pegasus Lake were directly linked to the Lake Management Plan Objectives (Beca 2008) as described below:

- A 5 m lake depth to limit light for algae growth

- Gravel lining on the lake bottom to prevent weed growth and make it difficult for vegetation to establish
- Retaining wall edge treatments to prevent erosion
- Localised iron slag treatment to strip phosphorus from runoff and shallow groundwater flows entering the lake
- Various lake shoreline treatments including rock outcrops, beaches and wetlands for visual interest (Photograph 2)
- Vertical draft tube mixers to prevent thermal stratification

Photograph 1: Images of Pegasus Lake.

The intended recreational and aesthetic objectives of Pegasus Lake are potentially at odds with a sustainable, natural ecosystem. The following sections assess how well this constructed urban lake is meeting its design and management objectives, and discuss other issues which have arisen.

3 SUMMARY OF MONITORING

Upon completion of the construction and filling of Pegasus Lake, monitoring commenced as part of the resource consent requirements. Monitoring was carried out on a monthly basis by Golder on behalf of TPPTL. Samples were collected from two sites on Pegasus Lake and from three sites in the ECMA, described below:

- Jetty 1, a jetty adjacent to the Yacht Club on the western shore of Pegasus Lake
- Mid Lake, a sampling site in the middle of Pegasus Lake
- ECMA 1, the northernmost sampling location in the ECMA
- ECMA 2, a location adjacent to the southern discharge weir from the lake
- ECMA Outlet, the outlet of the ECMA

On-site monitoring of pH, water temperature, conductivity and dissolved oxygen concentrations (DO) was undertaken on a monthly basis. Visual clarity was measured using a clarity tube and a secchi disk.

Water samples were submitted to Hill Laboratories for the analysis of total suspended solids (TSS), turbidity, dissolved copper, dissolved zinc, chlorophyll *a*, Escherichia coli (*E. coli*) and nutrients (e.g., ammoniacal nitrogen, total Kjeldahl nitrogen, nitrate nitrogen, nitrite nitrogen, total oxidised nitrogen, total nitrogen (TN), dissolved reactive phosphorus (DRP) and total phosphorus (TP)).

Commencing in December 2011, samples of lake water from Jetty 1 were submitted for algal analysis to the National Institute of Water and Atmospheric Research (NIWA) Algal Services Laboratory in Hamilton to check for the presence of toxic algae and counts of total algae.

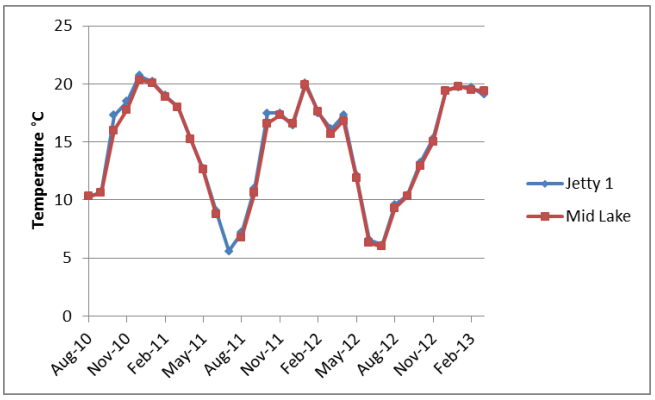
4 WATER QUALITY RESULTS

A brief summary of water quality in Pegasus Lake (at sampling locations Mid Lake and Jetty 1) based on monthly sampling for the period August 2010 to February 2013 is provided below.

4.1 TEMPERATURE AND DISSOLVED OXYGEN

A clear seasonal trend in temperature is exhibited in Pegasus Lake with low winter temperatures around 5°C and high summer temperatures around 20°C (Figure 2). The Australian and New Zealand Environmental Conservation Council (ANZECC) Guidelines for fresh water quality (2000) recommend that temperatures remain within the range 15°C to 35°C for primary contact recreational activities. During the winter months, temperatures drop below this range in Pegasus Lake. However, this is expected in the southern parts of New Zealand and during these periods the demand for contact recreation is relatively low.

Dissolved oxygen and water temperature are critical factors that affect the ability of aquatic organisms to thrive (CRC 2011). Measurement of DO in the lake showed that DO concentrations at the surface generally remained above the minimum recommended level of 80 % (ANZECC 2000) (Figure 2).



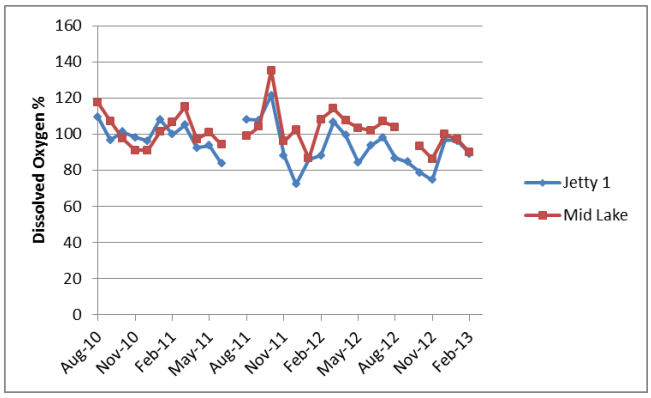


Figure 2: Temperature and DO in Pegasus Lake from August 2010 to February 2013.

At the Mid Lake sampling location, the concentration of DO and temperature was measured with depth to provide data on the DO profile in the lake as an indicator of lake stratification. The lake typically showed minimal change in temperature or DO with depth; any vertical variation in temperature and DO was small and gradual. Thus, the temperature and DO vertical profile data were indicative of well-mixed conditions and lake stratification was not evident.

4.2 PH

The water in Pegasus Lake was characterized by a neutral to alkaline pH (ranging from 7.5 to 9.8) with little month to month variation (Figure 3). The Canterbury Natural Resources Regional Plan (NRRP) (CRC 2011) does not specify a pH range for lakes of this type, however it recommends a range of 6.5 to 8.5 for high country lakes and all types of rivers. The ANZECC guidelines (2000) recommend that pH is maintained in the range of 5.0 to 9.0. Pegasus Lake exceeded the upper guideline on three occasions during the past two and a half years.

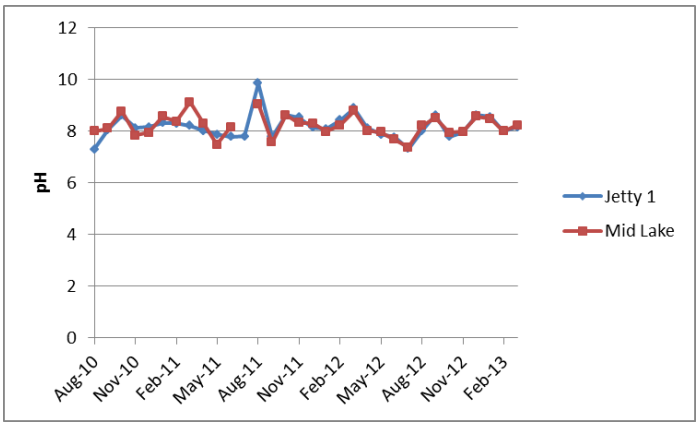


Figure 3: pH in Pegasus Lake from August 2010 to February 2013.

4.3 DISSOLVED COPPER AND ZINC

Dissolved copper in the lake showed declining concentrations from an initial high of 0.0031 g/m³ in August 2010, to below the detection limit of 0.00050 g/m³ by October

2011 (Figure 4). Since October 2011, dissolved copper concentrations have been consistently below the detection limit.

Concentrations of dissolved zinc showed a similar overall trend, with a decline from an initial high of 0.0026 g/m³ in August 2010, to below the detection limit of 0.00050 g/m³ by January 2012 (Figure 4). Concentrations of dissolved zinc showed more variation, with detection varying month to month. Since January 2012, dissolved zinc concentrations have been consistently below the detection limit.

The decline in dissolved metals occurred over a period of approximately one year following the filling of the lake. Initial concentrations may be linked to construction activities which deposited contaminants into the lake. However, currently less than a quarter of potential homes have been completed in the development, so there is potential for contaminant inputs to increase over time. As the development of Pegasus Town progresses and vehicular movements increase, an increase in dissolved metal contaminants may occur, although treatment measures are in place to prevent this.

The Canterbury NRRP (CRC 2011) places a 95% level of protection on aquatic ecosystems for artificial lakes. The relevant guideline values for copper and zinc are 0.0014 g/m³ and 0.0080 g/m³, respectively, although these refer to total rather than dissolved concentrations. Since stabilization of Pegasus Lake, concentrations of zinc and copper have been consistently below these limits.

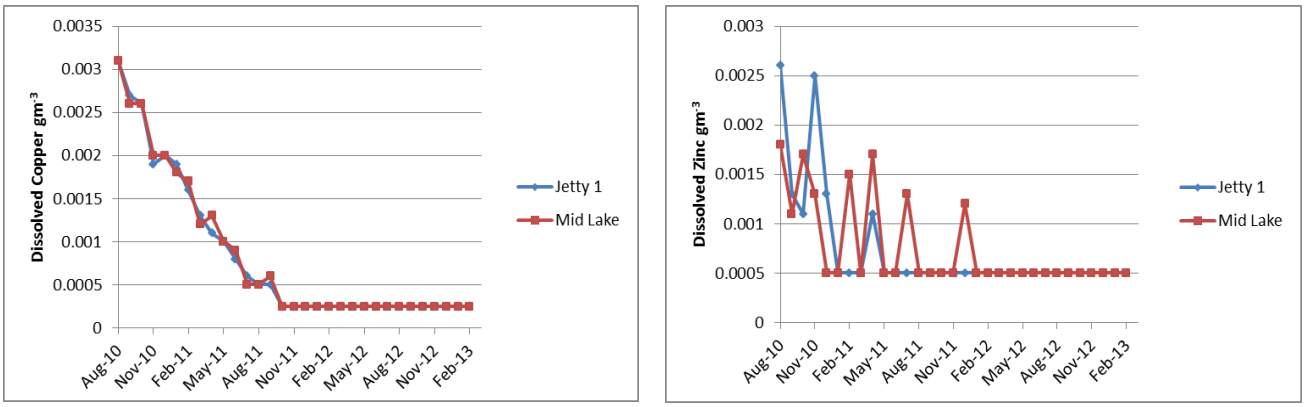


Figure 4: Dissolved copper and zinc in Pegasus Lake, August 2010 to February 2013.

4.4 WATER CLARITY

TSS concentrations in Pegasus Lake reached a maximum of 12.0 g/m³ at both the Mid Lake and Jetty 1 sites in October 2012. Turbidity reflected similar variability to TSS, with a concurrent peak in turbidity around September 2012 (Figure 5). Turbidity in the lake tended to be lower in the summer months from November to February each year. Clarity, as measured with a clarity tube, was consistently above 70 cm with the exception of the period leading up to September 2012.

The ANZECC guidelines (2000) for recreational use, recommend a black disk should be visible from at least 1.6 m away for primary contact recreation. Except for September 2012, this target was achieved at Mid Lake on all occasions. Secchi disk depth was limited at Jetty 1 by the depth to the lake bed. The complementary measures of turbidity, TSS and clarity, support the generally clear nature of the lake. The decline in

water clarity occurring in September 2012 coincided with maxima values for turbidity and TSS (Figure 5). This event is discussed further in Section 4.9.

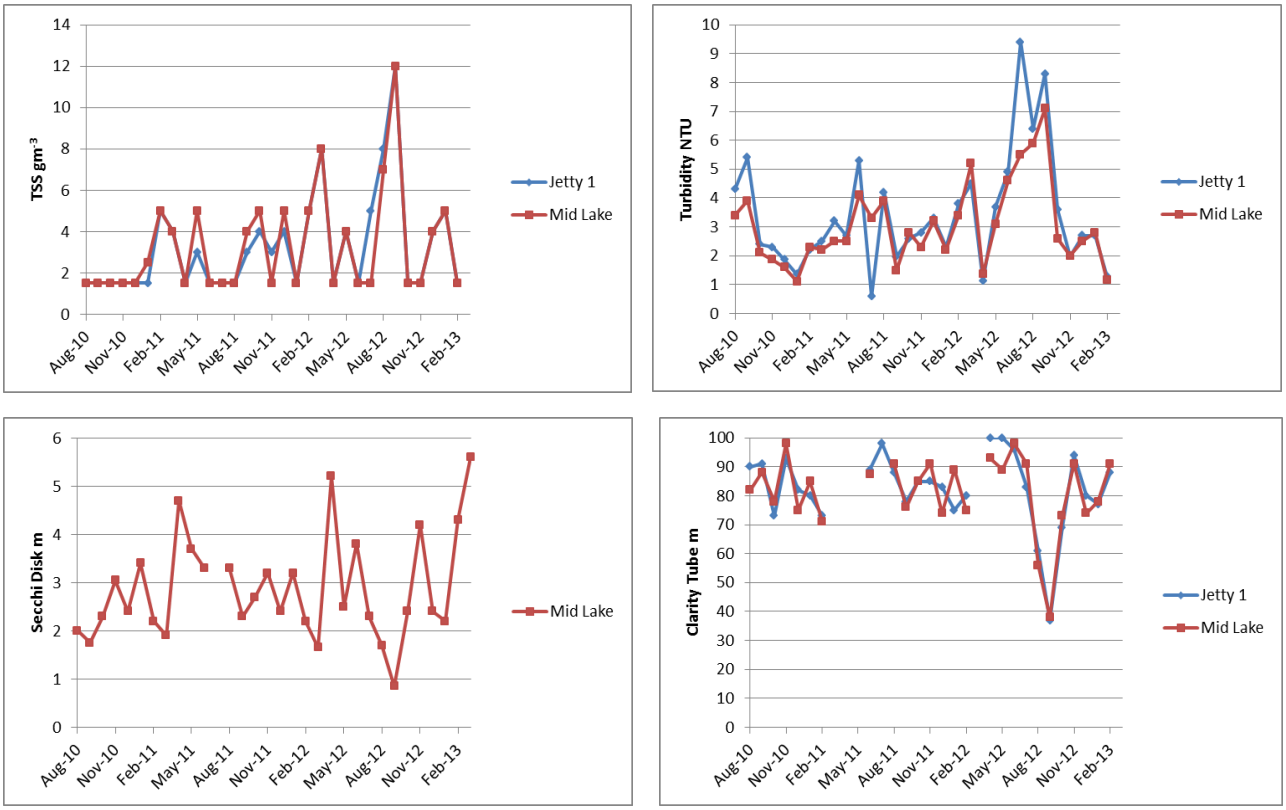


Figure 5: Water clarity in Pegasus Lake from August 2010 to February 2013.

4.5 NITROGEN

The concentrations of TN in the lake were initially about 1.2 g/m³ in August 2010. However, since November 2010, concentrations have averaged around 0.38 g/m³ (Figure 6). The Canterbury NRRP (CRC 2011) recommends a maximum TN concentration of 0.34 g/m³ for artificial lakes. Pegasus Lake is nitrogen enriched, which contributes to its eutrophic or supertrophic state.

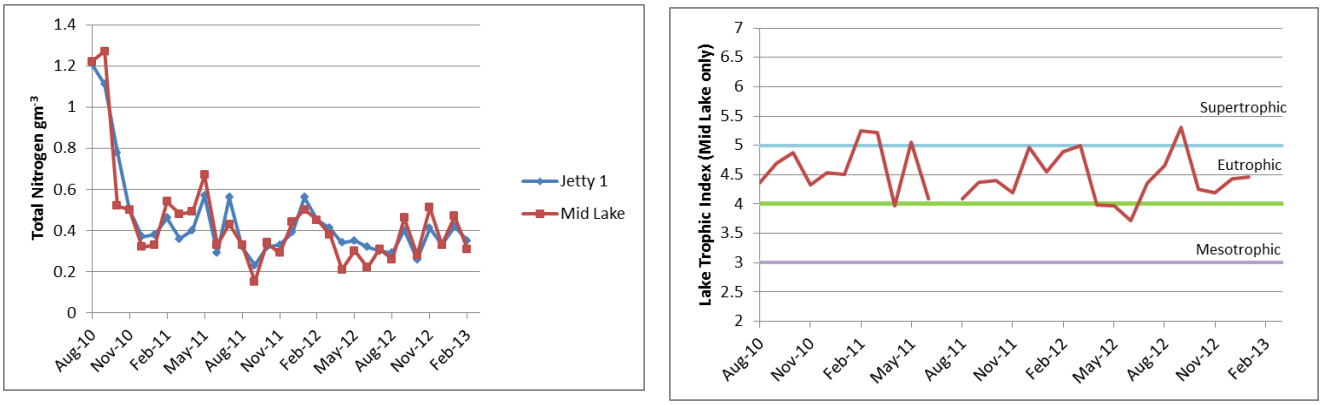


Figure 6: Nitrogen and trophic level in Pegasus Lake from August 2010 to February 2013.

4.6 PHOSPHORUS

Throughout the period of monitoring to date, TP concentrations generally followed similar trends to the concentrations of DRP (Figure 7). An elevation in phosphorus concentrations occurred in the lake during late 2010 to mid 2011, however concentrations have reduced to approximate the initial concentrations evident post-filling of Pegasus Lake.

The Canterbury NRRP (CRC 2011) recommends a maximum TP concentration of 0.020 g/m³ for artificial lakes. Pegasus Lake has consistently shown concentrations of TP elevated above this recommended value. This has contributed to the eutrophic nature of the lake and provides nutrients for the growth of aquatic plants and algae.

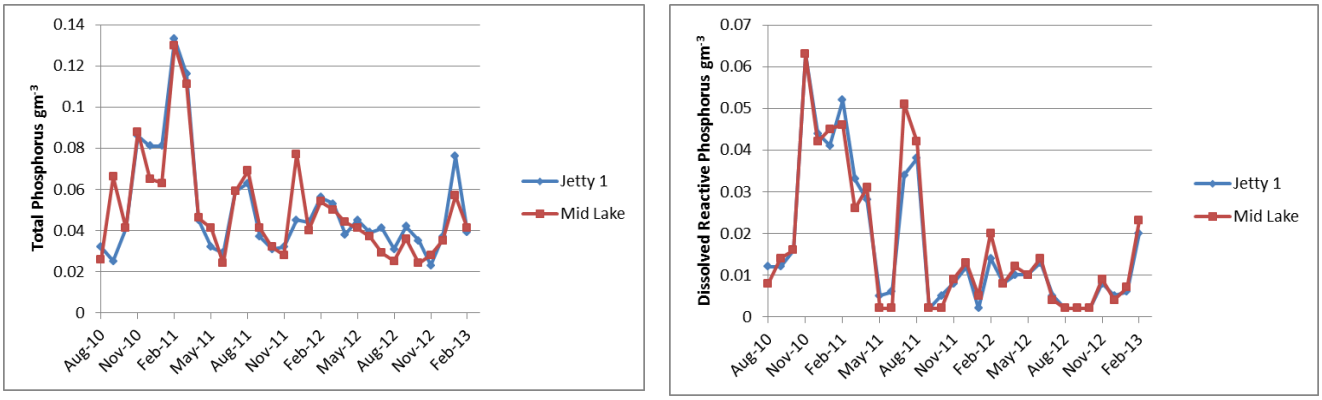


Figure 7: Phosphorus in Pegasus Lake from August 2010 to February 2013.

4.7 CHLOROPHYLL-A

Two spikes in chlorophyll *a* were observed in the lake during May 2011 and September 2012 (Figure 8). Overall there is a trend for chlorophyll *a* concentrations to increase gradually through summer. Counts of chlorophyll *a* provide an indication of potential algae numbers which, if allowed to proliferate, can lead to aesthetic issues.

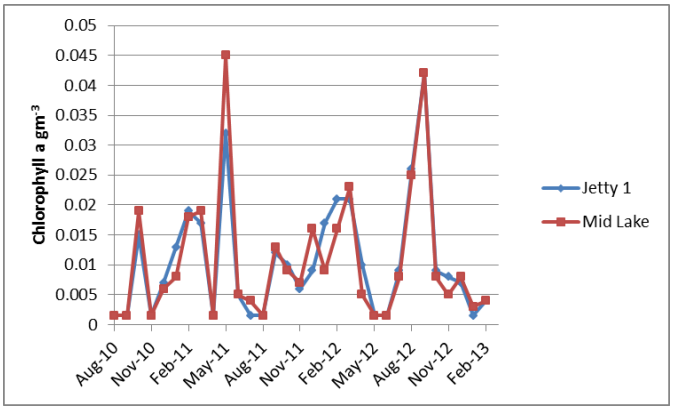


Figure 8: Chlorophyll a in Pegasus Lake from August 2010 to February 2013.

4.8 BACTERIAL INDICATORS

E. coli counts in the lake have tended to remain less than 10 cfu/100 mL, with the exception of 2 events (Figure 9). Populations were high over the summer months in early 2011 (50 cfu/100 mL), with a reduction by winter. By July 2012 the numbers of *E. coli* rose again, up to a peak of 70 cfu/100 mL. *E. coli* populations are significantly lower in the lake when compared to the ECMA, due to the increased presence of birdlife.

The concentration of faecal micro-organisms in water is used to indicate the risk of illness for humans from the involuntary ingestion of water during contact recreation (CRC 2011). Pegasus Lake *E. coli* levels have at all times remained well below the Bathing Water Quality Guideline of 260 cfu/100 mL (MfE 2003).

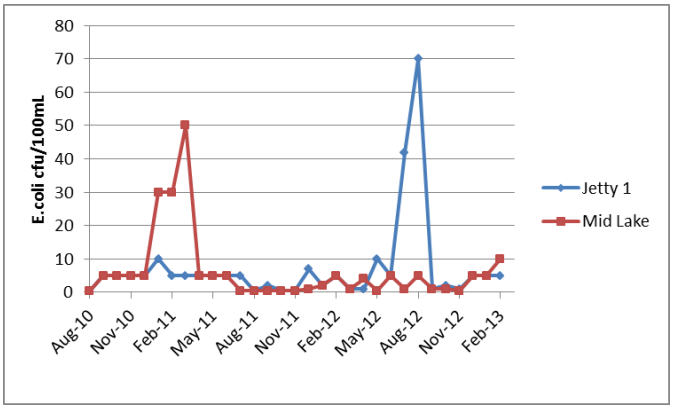


Figure 9: E. coli *in Pegasus Lake from August 2010 to February 2013.*

4.9 AESTHETIC CHANGES

From the start of regular monitoring in Pegasus Lake in August 2010, visual observations concerning the colour, appearance and presence of any unsightly scums, films or rubbish were noted during each monthly monitoring visit in fulfillment of Condition 5 of the consents. Up to 2012, no aesthetic issues had been raised. The colour of lakes in Canterbury is naturally highly variable between lakes (CRC 2011).

In September 2012 concern was raised about lake aesthetics when the lake appeared to be orange-brown in colour, had visible weed growth and iron-stained precipitate was visible (Photograph 2). In response to these aesthetic changes, Golder, on TPPTL's behalf, undertook additional dissolved iron, chlorophyll *a*, cyanobacteria and total algae sampling at the regular sampling site Jetty 1. To assess the extent of the influence across Pegasus Lake, sampling for a suite of 15 parameters was undertaken at 3 additional sites on Pegasus Lake on 12 September 2012.

Earlier laboratory analysis of groundwater results were reviewed and this indicated that groundwater in the area contained dissolved iron (0.28 g/m^3). As groundwater has been noted to naturally enter Pegasus Lake this was considered a contributor to the aesthetic changes noted above.

Throughout 2012, testing for levels of total algae had also occurred on a monthly basis. Through this additional testing, it had been noted that in September 2012, the total algae count was almost twice as high (21,084 cells/mL) as any other month monitored to date. It is suggested that, combined with higher concentrations of iron in seasonally high influent groundwater, the algae became iron-stained, effectively making the water column appear browner and more turbid than normal.

Weed growth also appeared to accelerate at the time, which contributed to the overall poor aesthetics of Pegasus Lake.

Photograph 2: Images of discolouration in Pegasus Lake during September 2012.

TPPTL undertook immediate measures to improve the aesthetics of Pegasus Lake. The lake outflow weirs were manipulated to increase throughflow and flush the lake. Weed was removed manually and also sprayed in early November 2012. The spray programme was successful and led to the removal of all significant visible weed.

It is considered that the decline in clarity observed in September 2012 was a seasonal phenomenon driven primarily by high groundwater levels and an increase in lake water temperature causing algal growth. During the following sampling rounds, the colour and clarity of Pegasus Lake improved, and total algae counts reduced.

Although the dramatic aesthetic changes noted in September 2012 have not occurred in previous years, it is possible that they could reoccur in the future. Retention of an appropriate recreational aesthetic will require continued investment into maintenance and response actions, refer to Section 5 below.

4.10 CYANOBACTERIA

4.10.1 INTRODUCTION

Cyanobacteria (blue-green algae) are microscopic photosynthetic organisms which are common and naturally occurring in aquatic ecosystems. They can be in either a planktonic form (free floating) or a benthic form (bottom dwelling) (Cooperative Research Centre for Water Quality and Treatment 2010). Some cyanobacteria are known to produce toxins which can be harmful. Naturally occurring cyanobacteria are found throughout the country, but only form problematic blooms at some sites under the right conditions (CRC 2013).

4.10.2 PRESENCE IN PEGASUS LAKE

Cyanobacteria have regularly been identified in Pegasus Lake at low levels (<50 cells/mL). The New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters

(MfE 2009) provides a framework by which the levels of cyanobacteria can be monitored and appropriate actions taken. The framework is summarised below:

Alert Level	Threshold	Actions
Surveillance (Green mode)	a) The cell concentration of cyanobacteria is <500 cells/mL b) The biovolume equivalent is <0.5 mm^3/L	Continue monitoring
Alert (Amber mode)	The biovolume equivalent is between 0.5 mm^3/L and 1.8 mm^3/L	Notify Public Health authorities and increase monitoring
Action (Red mode)	The biovolume equivalent is >1.8 mm^3/L	Notify the public of potential health risk and increase monitoring

Table 1: Summary of alert-level framework for planktonic cyanobacteria.

Sampling undertaken on 11 July 2012 indicated the presence of the potentially toxic blue-green algal (cyanobacteria) species Dolichospermum circinalis in levels well above previous sampling results (1,759 cells/mL) (Golder 2012a). It is important to note that cell counts above the 500 cells/mL alert threshold do not necessarily equate to an excedence of the biovolume threshold, hence the need for the two measurements.

Analysis of cyanobacteria was undertaken by NIWA which holds IANZ accreditation for algal analyses (including cyanobacteria). An additional NIWA report concluded that the biovolume equivalent concentration of 0.36 mm^3/L was within the 'Surveillance – Green mode' of the cyanobacteria guidelines (threshold for Alert – Amber mode is 0.5 mm^3/L).

This result was of interest to CRC and was further investigated by Golder on behalf of TPPTL for the following reasons:

- High numbers of blue-green algae have the potential to cause 'blooms' which are unsightly and if the species causing the bloom produces toxins then there is a risk to users of the lake (humans and dogs) and the public health unit may need to be notified.
- The species responsible for the high numbers (Dolichospermum circinalis) had not been recorded in the lake in any of Golder's previous sampling rounds and it is a potentially toxic species.
- It was not typical to see a sudden increase in algal species during the cold winter months when algae typically do not proliferate.
- Golder checked the Environment Canterbury website to determine whether any toxic algal bloom alerts had been issued for other waterbodies in the region however none were apparent (www.ecan.govt.nz 13 July 2012).

Although the result was within the 'Surveillance – Green mode' the potential remains, as in any waterbody, for a potentially toxic bloom to occur. A series of management steps was therefore created as discussed in Section 5.

5 PEGASUS STRATEGIES FOR MANAGEMENT OF WATER QUALITY AND AESTHETICS

Pegasus Lake generally meets its consent requirements for water quality, however an analysis of the big picture shows that some of the issues are both caused and solved by the manmade nature of the lake.

Design features such as hard shore edge treatments have the advantage of reducing erosion and TSS inputs to the lake, but also limit the ability for riparian vegetation to; provide habitat for aquatic fauna which in turn improve water quality; and shade the lake to reduce temperature extremes and limit light for algae growth.

The desired clarity and aesthetic appeal of the lake, is tempered by the ease by which weed proliferates in clear waters, and the extensive maintenance efforts required to remove and maintain the lake's visual amenity.

Pegasus therefore employs a number of maintenance tasks and measures, in order to manage weed, cyanobacteria and the bathing water quality of Pegasus Lake.

5.1 ROUTINE MAINTENANCE FOR WEED, AESTHETICS

To manage aesthetic lake issues such as weed growth, colour changes and rubbish, Pegasus staff use the following measures:

- increase throughflow/reduce residence time by changing weir heights to encourage flushing of the lake.
- limit supply of nutrients by managing the fertilisation of grassed lake verges and removing grass clippings,
- removal of decaying vegetation from lake
- spraying of weed when required
- minimise temperature increases by using vertical mixers
- collect/remove windblown litter/debris

5.2 CYANOBACTERIA MANAGEMENT

Cyanobacteria naturally occur in water bodies, and are only an issue when they increase in concentrations high enough to form blooms. In order to manage and respond to any elevated counts of cyanobacteria, and ensure the safety of recreational users of Pegasus Lake, the following measures were recommended and undertaken (Golder 2012a):

- Increase sampling frequency of cyanobacteria to fortnightly over the summer period.
- Cyanobacteria biovolumes are monitored in accordance with the New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters (MfE 2009). Should any sample exceed the biovolume equivalent of 0.5 mm^3/L, then the 'Alert – Amber mode' measures will be undertaken.
- In the event of elevated cell counts (but still within 'Surveillance – Green mode'): increase sampling to weekly for at least the following two to three weeks in order to establish whether the potentially toxic species are in a proliferation phase or die-off phase.

- NIWA to include the biovolume equivalent calculation as part of future results reports, in the event that the cell count exceeds 500 cells per mL.
- The results are forwarded to Canterbury Regional Council and Waimakariri District Council.
- Visual inspections continue for the presence of benthic cyanobacteria.

5.3 MANAGEMENT OF BACTERIAL INDICATORS

To limit levels of bacteria entering Pegasus Lake, the following preventative measures are used (Beca 2007):

- discourage particular birds from the lake by keeping grass verges short to discourage nesting
- disturb birds if they try to nest and monitor their numbers
- public education; visitors told not to feed birds
- ensure appropriate stormwater treatment of water entering the lake

Due to the popularity of Pegasus Town during the summer months for contact recreation activities, and the potential risk to users if microbiological numbers were to rise, TPPTL committed to the actions below (Golder 2012b):

- Summer sampling increased in frequency to weekly for *E. coli.*
- The results are forwarded to Canterbury Regional Council and Waimakariri District Council.
- *E. coli* concentrations are monitored in accordance with the freshwater surveillance, alert and action levels in the Microbiological Water Quality Guidelines for Recreational Water Quality (MfE 2003). Should any single sample of *E. coli* exceed 260 MPN/100 mL, then the amber alert mode measures will be undertaken. Should any single sample of E. coli exceed 550 MPN/100 mL, then the red action mode measures will be undertaken.

6 SUITABILITY OF LAKE WATER QUALITY FOR ITS DESIGNED USES

Pegasus Lake is used for a wide range of recreational activities on and off the water. The water quality in the lake is suitable for secondary contact recreation and the lake is used extensively for these activities. Based on the recent summer water quality monitoring, the lake has been suitable for primary contact recreation and has become a popular location for swimming.

The dissolved oxygen profile data collected during the 2011-2013 monitoring period suggests that persistent seasonal stratification is not occurring in the lake. The lake is well oxygenated and it is considered to be well mixed.

Monitoring for toxic algae has shown that potentially toxic algal species are present in very low concentrations in the lake and the risk of a bloom forming is therefore considered to be low. During all monitoring occasions, cyanobacteria cell counts reported have been well within the green surveillance mode (MfE 2009), and therefore give no cause for concern. Resource consent conditions have been met in full as there

are no toxic algal blooms and the lake remains suitable for primary and secondary contact recreation.

Management of the lake for visual aesthetics and recreation is considered to be appropriate and the water quality data does not suggest that changes to the management regime are warranted to ensure ongoing compliance with the objectives of the Lake Management Plan. Overall, Pegasus Lake goes above and beyond its consent requirements and Lake Management Plan objectives, by providing a recreational resource suitable for primary contact recreation.

7 CONCLUSIONS

Pegasus Lake represents an engineered system constructed to mimic a natural ecosystem. A balancing act exists between creating a 'swimming pool', which meets the recreational, aesthetic and water quality requirements; and a 'natural lake or wetland' which provides ecosystem richness and diversity, cultural objectives and natural capacity for flood storage.

Cyanobacteria, aesthetic changes and bacterial contamination are all legitimate and potential risks to the water quality in the lake. Pegasus Lake will require ongoing maintenance and management; otherwise it will evolve to a more natural state, likely to be outside of the objectives of the Lake Management Plan.

From a consenting perspective, care must be taken in prescribing the 'ruler' by which a successful lake is measured. Does recreational value come before ecological value? Is the water colour really important? What should a lake look like and be used for?

As it is however, it achieves its purpose and more; Pegasus Lake is safe for both primary and secondary contact recreation and provides visual amenity in a clean and tidy manner. However, it does exhibit a slightly different aesthetic than expected; in terms of its darker green colour. Overall, Pegasus Lake succeeds in providing an excellent basis for recreation activities as an accessible fresh water resource for Pegasus Town and the wider Canterbury region.

ACKNOWLEDGEMENTS

Todd Property Pegasus Town Limited – Paul Armstrong and Richard Thoms

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