Water Supplementation for Thomsons Lake Nature Reserve

Review of the 2016 Supplementation Program

1. BACKGROUND AND PURPOSE

A water supplementation program was first trialled at Thomsons Lake in winter 2004 and, due to its observed success, has been continued every winter since. The program aims to ensure that Thomsons Lake contains enough water in late spring and early summer to support the resident and migratory waterbird population. In addition, ensuring the lake contains water for a longer period in early summer will allow the resident cygnet population to mature enough to enable them to fly over the vermin proof fence surrounding Thomsons Lake Nature Reserve, to find alternative water sources.

Given the apparent positive impact of the 2015 water supplementation program on the Thomsons Lake ecosystem, the 2015 review recommended that the supplementation program be implemented again by the Regional Parks Unit of the Department of Parks and Wildlife, in winter 2016.

As outlined in the *Water Supplementation Operational Management Plan for Thomsons Lake Nature Reserve - July 2004* (cited as the *Operational Management Plan*), the purpose of the annual review is to determine:

- whether there have been any detrimental impacts on Thomsons Lake;
- the appropriateness of nutrient concentration guidelines;
- the extent of the supplementation period; and
- whether supplementation should continue to occur in the future.

2. OVERVIEW OF THE SUPPLEMENTATION PROGRAM IN 2016

Supplementation period

The supplementation period commenced on 1 July due to consistent rainfall through the late part of June and it ceased on 15 September when water levels were close to the level at which supplementation should be stopped as recommended in the *Operational Management Plan* (12.6 m).

At the end of September other nearby lakes were also close to capacity due to the high rainfall, including nearby Yangebup Lake which was close to reaching its control drainage water level. At this point, water is meant to be pumped into Cockburn Sound, however, due to vandalism at the pump house and other operational issues, the Water Corporation could not discharge to Cockburn Sound. The department received a request to allow drainage water into Thomsons Lake to alleviate flooding risk; this was achieved by lessening the volume flowing north through the South Jandakot Drainage Scheme into Yangebup Lake. Supplementation therefore recommenced from 30 September to 17 October 2016.

Overall, supplementation occurred for a total of 93 days, 31 days more than recommended in the *Operational Management Plan*.

The annual climate summary for Perth outlines that rainfall in 2016 was near average, but it was the wettest year for three years at Jandakot airport, the nearest official Bureau of Meteorology recording station. Annual mean maximum temperatures in 2016 were below average across Perth, and it was the coolest year for over a decade at most sites.

Monitoring

As in previous years, a number of parameters were monitored at Thomsons Lake over spring and summer 2016/2017 which assisted in determining the effectiveness of the water supplementation program (see Table 1).

Table 1. Monitoring parameters, monitoring agencies and relevant monitoring projects undertaken at Thomsons Lake Nature Reserve.

Monitoring Agency/Group	Parameter	Monitoring project
Water Corporation	Water quality (including TP & TN), flow and water levels at Bartram Road Buffer Lakes and Russell Road Buffer Lake. Water levels at Thomsons Lake.	Operation of the Southern Lakes Drainage Scheme.

Bennelongia Environmental Consultants on behalf of the Department of Water	Macroinvertebrate diversity, water quality and depth at Thomsons Lake.	Jandakot Wetland Monitoring: Annual Report 2016 (March 2017).

Water levels and comparison to previous years

Water Corporation data shows a maximum water level at Thomsons Lake of 12.62 mAHD. This was attained in October and the lake bed dried by early February 2017. Complete drying usually occurs during January, February or March so 2016 was average.

Table 2. Maximum water levels at Thomsons Lake, and annual precipitation at Jandakot airport.

Year	Water level (mAHD) *	Annual Precipitation (mm)
2016	12.62	794.2
2015	12.15	651.2
2014	12.37	690.6
2013	12.51	889.0
2012	12.17	684.4
2011	12.28	915.6
2010	12.06	495.8
2009	12.68	687.6
2008	12.68	869.4
2007	12.42	816.8
2006	12.04	509.8
2005	12.92	945.8
2004	12.47	685.4
2003	12.46	714.0
2002	12.24	758.0
2001	12.24	715.6
2000	12.64	982.4

* Note: lake bed level varies between 11.5 mAHD (level at which Water Corporation's staff gauge dries) and 11.8 mAHD in Maher and Davis (2009).

The 794.2 mm rainfall recorded for the year at Jandakot Airport was ranked as average for the site (96% of annual average of 823.5 mm) (Bureau of Meteorology 2017).

Supplementation water sources

Prior to 2008, supplementation occurred entirely from the Bartram Road Buffer Lakes outfall, immediately to the east of Thomsons Lake. This water is piped into the South Jandakot Branch Drain and diverted into an open channel leading into Thomsons Lake by means of adjustable weir boards within an access chamber on the Branch Drain. In 2008, the Water Corporation completed works on what it calls the "Russell Road Buffer Lake" (also known as Lake Copulup), the outflow from which was channelled directly into the South Jandakot Branch Drain (along with overflow from the "Boronia Gardens" subdivision), located upstream of the Bartram Road Buffer Lakes outfall junction. This means that supplementation waters now originate from two distinct sources, which currently cannot be separated.

It is to be noted that testing of the Russell Road Buffer Lake outflow in August 2008 indicated the water quality was substantially poorer than the Bartram Road Buffer Lakes outflow. Ongoing testing reveals there to be only a slight improvement in water quality since connection and it may be many years before the water quality approaches that flowing from the Bartram Road Buffer Lakes.

Drainage water quality and comparisons with previous years

Water quality monitoring undertaken by the Water Corporation indicated that during the 2016 water supplementation period (from 1 July to 15 September 2016 and also from 30 September to 17 October), the Bartram Road Buffer Lakes outflow had Total Phosphorus levels ranging between a 98 µg/L minimum and a 270 µg/L maximum, with an average reading over the period (from 36 samples) of 129 µg/L (unfiltered). This value is below the [250 µg/L and 300 µg/L] target range specified in the *Operational Management Plan* and is comparable to levels recorded in the four previous years during the supplementation regime (180, 220, 120 and 150 µg/L in 2012, 2013, 2014 and 2015 respectively).

(Note, µg/L is more commonly reported in the literature so the units of mg/L used by the Water Corporation have been changed to µg/L, where 1 mg/L = 1,000 µg/L.)

Sampling of the Russell Road Buffer Lake outflow revealed Total Phosphorous levels ranging between a 270 µg/L minimum and an 830 µg/L maximum, with an average reading over the period (from 19 samples) of 516 µg/L. This value represents a substantial decrease in Total Phosphorus level since last year's average of 930 µg/L, though still above the expected [250 µg/L and 300 µg/L] target range specified in the *Operational Management Plan* and significantly higher than the average Total Phosphorous in the Bartram Road Buffer Lakes outflow (129 µg/L).

The figures above provide an assessment of Total Phosphorus levels in the outflows of the buffer lakes, prior to entry into Thomsons Lake. Water Corporation data shows that Total Phosphorus levels were lower in the Bartram Road Buffer Lakes during early October, than during the main supplementation period. However they were slightly higher from the Russell Road Buffer Lake, such that the maximum increased from 680 µg/L to 830 µg/L and the average increased from 445 µg/L to 516 µg/L.

The average Total Phosphorus reading for the Russell Road Buffer Lake outflow has been outside of the target range every year since 2008 when it was first directed into the South Jandakot Branch Drain, except for 2011 when an average of 300 µg/L was attained. A declining trend was noted between 2008 and 2012 but since 2013 the average readings have been substantially higher, the cause of this increase is not clear.

For Russell Road Buffer Lake outflow the average reading for Total Nitrogen is three times higher than for Bartram Road Buffer Lakes outflow (3,752 µg/L and 1,236 µg/L respectively), while the average reading for Ammonia (as N filtered) is around 20 times higher (502 µg/L and 26 µg/L, respectively). Ammonia (as N filtered) is much lower this year, for both lakes, than it was than 2015 (1,060 and 90 ug/l respectively before). Unmonitored inflow from the adjacent Boronia Gardens development is an unknown quantity, however this is understood to be relatively minor, and should only occur during periods of heavy rainfall, when considerable catchment flushing has already occurred.

Bennelongia Environmental Consultants also undertook some physico-chemical monitoring of Thomsons Lake itself on behalf of the Department of Water in 2016. The Department of Water has a requirement to report to the Office of the Environmental Protection Authority on a number of parameters, as part of Ministerial Statement No. 688 which relates to groundwater abstraction from the Jandakot Mound. The monitoring has been undertaken by a number of consultancies since 1996 (Table 3).

The *Jandakot Wetland Monitoring: Annual Report 2016* (Bennelongia 2017) shows that from one water sample taken at Thomsons Lake in spring 2016, a Total Phosphorus level of 60 µg/L and a Total Nitrogen level of 2,000 µg/L were recorded. Overall the nutrient values appear to be similar to previous years, and were still reduced from 2010 when the low water level appears to have been the main factor influencing water quality. Water chemistry data were generally within historic ranges being weakly acidic (last recorded in 2012), brackish, lightly coloured and nutrient-rich. It is noted in the annual report that the artificial maintenance of water levels to sustain conservation values may affect water chemistry parameters.

Table 3. Water quality data at Thomsons Lake (in spring) over the period 1996 to 2016*

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Depth (m)	0.95	0.51	0.43	0.67	0.90	0.49	0.42	0.67	0.66	1.13	0.25	0.67	0.93	0.93	0.31	0.53	0.42
pH	9.1	9.35	9.78	7.88	9.87	7.49	9.76	8.03	9.85	7.96	9.94	7.49	7.9	9.19	8.68	8.55	6.3
Conductivity(µS/cm)	3200	6430	4321	2190	3120	3660	6560	1693	3200	2430	5570	3030	2343	2270	4553	2370	2760
ortho-P(µg/L)	112	2	4	15	7	11	7	10	22	4	8	8	7	4	12	6	3
organic-P(µg/L)	82	116	87	110	122	289	43	60	6	45	66	46	56	25	168	35	33
TP(µg/L)	194	118	91	125	129	300	50	70	28	49	74	54	63	29? (67)	180	41	36
NH4(µg/L)	22	12	6	33	29	36	40	43	16	13	27	11	17	20	77	13	40
NOX(µg/L)	10	11	9	14	18	14	28	15	9	5	10	3	4	2	4	5	11
organic-N(µg/L)	3650	3892	3152	3902	5065	6750	4532	3742	3275	2882	4863	2786	2889	1978	5219	2582	2949
TN(µg/L)	3682	3915	3167	3949	5112	6800	4600	3800	3300	2900	4900	2800	2900	2000	5300	2600	3000
Chl *a* (µg/L)	1.1	16.6	12.3	10.2	61	63	1	0.9	0.6	3	6.6	0.5	7.8	1.5	3	8	2.7
Phaeophytin (µg/L)	5.3	6.7	3	3.9	12.3	63	0.8	3.9	n/a	0.5	2.2	1	0.6	0.5	0.8	1.8	1.5
Turbidity (NTU)	2.1	4	6.5	26	16.5	27	n/a	2.7	1.55	0.97	3.14	2.49	4.55	1.43	3.71	2.18	1.59
Colour (g440/m)	20.95	6	7.83	23.49	15.1	22.7	n/a	19.8	7.3	21.6	6.67	10.9	21.6	9.3	12	18	12

*__Source__: Strehlow *et al* 2013 (p76) for 1996 – 2012 data

	2013	2014	2015	2016
Mean sampling depth (m)	0.43	0.38	0.15	0.34
pH	8.59	7.96	7.8	6.32
Conductivity(µS/cm)	2447	3547	3710	2320
ortho-P(µg/L)	<10	<10	0.04	-
organic-P(µg/L)	-	-	-	-
TP(µg/L)	70	30	40	60
NH4(µg/L)	<10	<20	0.05	10
NOX(µg/L)	<20	<10	<10	10
organic-N(µg/L)	-	-	-	-
TKN(µg/L)	3300	2900	3500	2000
Chl *a* (µg/L)	9	2	2	3
Phaeophytin (µg/L)	-	-	-	-
Turbidity (NTU)	3	2.1	1.6	2.7
Colour (g440/m or TCU True Colour Units)	14.4	14.4 or 200 TCU	375 TCU	100 TCU

*__Source__: Sampey *et al* 2014 (p25-28) for 2013 data
Bennelongia 2015, Bennelongia 2016 and Bennelongia 2017 for 2014 - 2016 data

Although Strehlow *et al* and Bennelongia both reported weakly acid conditions in 2012 and 2016, the Water Corporation's own sampling data for Thomsons Lake does not show such a trend during those same years. All samples are taken well away from the drainage outlet, in the south-western section of the lake however Bennelongia's samples are taken in-situ and the Water Corporation's samples are sent to a laboratory for analysis. It is unclear why the samples should record different results during the same period so this will be investigated further by the Regional Parks Unit for the 2018 sampling season.

Macroinvertebrate diversity

In addition to the water quality data that has been discussed, Bennelongia Environmental Consultants monitored the diversity and richness of macroinvertebrates on behalf of the Department of Water from 2014 to 2016. Murdoch University monitored the diversity and richness of macroinvertebrate families at Thomsons Lake between 1996 and 2012; in 2013 the monitoring was undertaken by Edith Cowan University. The 2016 sampling was undertaken at the same three sites as in previous years, and on this occasion the average water depth was approximately 20 cm deeper than the previous year.

Bennelongia 2017 reports that the total number of macroinvertebrate families recorded at Thomsons Lake in spring 2016 was 37, which is similar to last year (36 families in 2015), see Figure 1 below. The recorded value is significantly higher than the spring mean (1996-2016) for the species richness recorded in Thomsons Lake, which is 23.67. Water levels can impact on macroinvertebrate communities when they are extremely low but the 2016 levels were clearly adequate to support a rich community. There is no significant correlation between peak water level for Thomsons Lake between 1996 and 2016 and macroinvertebrate richness (Bennelongia 2017).

The abundance of macroinvertebrates was higher in the 2016 sampling round with 544 specimens recorded at Thomsons Lake (391 in 2015). The reasons for variation between sampling rounds are hard to pinpoint but may include climatic conditions around each sampling event and slight differences in habitat and spatial area covered; it is difficult to draw meaningful conclusions from these differences (Bennelongia 2017).

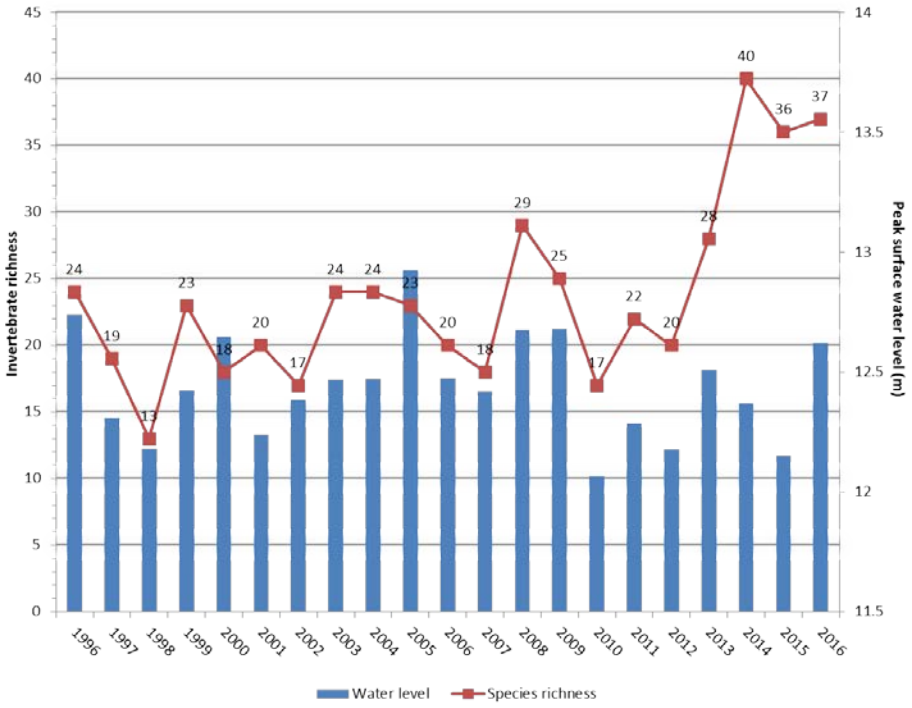
The 2012 monitoring report (Strehlow *et al* 2013) outlined that one requirement for the persistence of viable reproducing populations of macroinvertebrates is that the wetlands remain inundated (to a minimum depth of 0.5 m) for a minimum period of four to five months. Water Corporation data shows that the hydroperiod was greater in 2016 as the wetland remained inundated for over eight months between mid-May 2016 and early February 2017. In 2015 the hydroperiod had dropped to just three months.

The water depth recorded at the three monitoring sites ranged from 0.31 - 0.41 m (mean 0.34 m) in 2016, which is substantially greater than last year's mean water depth of 0.15 m. The water depth at Thomsons Lake has been below average for the last seven years (since monitoring began in 1996 the average water depth is 0.58 m).

The 2012 monitoring report (Strehlow *et al* 2013) identified that the maximum water depth data since 1971 clearly demonstrated a decreasing trend, while the 2016 monitoring report (Bennelongia 2017) concludes that water levels have been relatively constant over the last two decades. As discussed in the previous section, the report also concluded that water chemistry data recorded at Thomsons Lake this year were within historic ranges and showed no concerning trends. The supplementation program at Thomsons Lake appears beneficial but ongoing monitoring is required to ensure that this maintenance remains at sufficient levels to maintain ecological benefits.

The 2016 monitoring report (Bennelongia 2017) identified that threats to the conservation values of Thomsons Lake include declining water level as a result of groundwater abstraction and reducing rainfall, increasing urbanisation of the catchments leading to higher nutrient levels and the loss of lake habitats (open water and mudflats) because of invasion by introduced bulrushes. The use of pesticides to control mosquitos and non-biting midges is also noted however the department understands from the City of Cockburn that pesticides have only been used to control mosquitos (not midges) in the vicinity of Thomsons Lake (*pers. comm*. C. Beaton).

Figure 1. Peak water level (blue bars) and spring invertebrate richness (red line) recorded at Thomsons Lake over the period 1996 – 2016 *. The minimum number on the water level axis is the AHD (m) level at which the staff gauge dries.



*__Source__: Bennelongia Environmental Consultants 2017 (amended to show DEC's record of peak water level for 2006)

Waterbird observations

For a number of years, preliminary waterbird counts were supplied by Mike Bamford and Wes Bancroft (M.J. & A.R. Bamford Consulting Ecologists), who prepared an annual report on behalf of the Department of Water; these regular waterbird surveys ended in 2008. For 2009/2010 waterbird counts were supplied by Western Wildlife, undertaking observations under contract to AECOM environmental consultants. There has been no available data on waterbird observations for Thomsons Lake since 2010, nor has there been information available on signs of botulism in waterbirds at the lake.

As in previous years, cygnet patrols were carried out by the department during the latter part of the breeding season along the vermin-proof fence surrounding the lake. From December 2016 to early February 2017, 185 cygnets were found along the vermin-proof fence surrounding Thomsons Lake Nature Reserve, which were subsequently released through the fence into Kogolup Lake, immediately to the north. The lake did not dry out until early February 2017 so the high number of cygnets is likely to be due to multiple rounds of breeding. Whilst no cygnets were found stranded in 2010, 2009 and 2008, the numbers of stranded cygnets in other years since 2006 are shown in Figure 2 below.

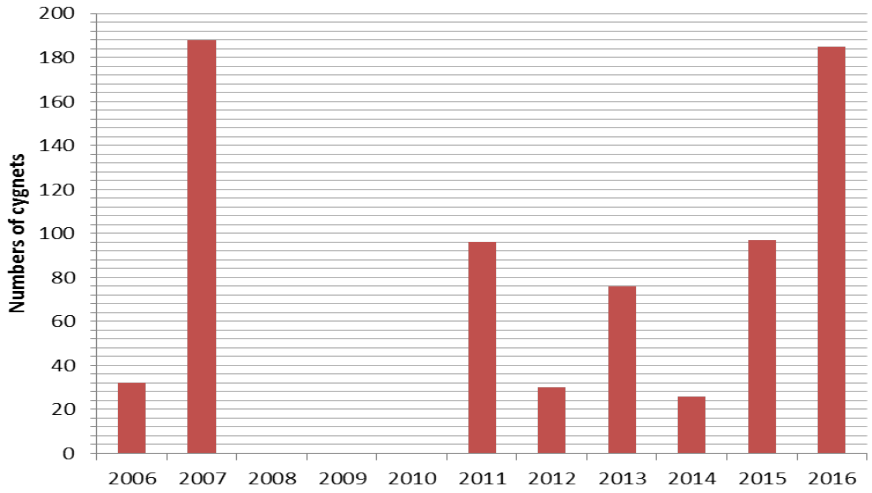


Figure 2. The number of cygnets rescued from the Thomsons Lake Nature Reserve vermin-proof fence through ranger-led summer patrols.

Ramsar Limits of Acceptable Change over 10 years

The Forrestdale and Thomsons Lake System was designated as a Wetland of International Importance under the Ramsar Convention in June 1990. A detailed Ecological Character Description (ECD) of the two sites and information on the condition of the ecosystem components and processes was prepared in 2009 (Maher and Davis 2009).

The department's review of the 2015 water supplementation program included a detailed review of available data from the 10 year period 2006-2015 to assess the condition of Thomsons Lake against the Limits of Acceptable Change (LAC) that were established in the ECD. The assessment showed that many of the LAC were being met in the majority of years, but for some key components and processes the LAC are either never being met or not being met in the majority of years. It is proposed that a detailed review of the LAC will be undertaken every two years; therefore the next LAC review will be undertaken when data from 2017 is available.

3. CONCLUSIONS

Water levels

Water Corporation data show the highest water level in 2016 was approximately 12.62 m AHD (recorded in early October), with the lake retaining water until early February 2017. It is seven years since the highest water level has been over 12.6 m AHD (see Figure 1) and this may be due in part to the additional drainage water received after the planned supplementation period.

Water quality

The extension of the supplementation period for 17 days in October did not appear to have a significant impact on nutrient levels entering Thomsons Lake. Recorded nutrient levels in the Bartram Road Buffer Lakes waters were below the limits specified in the *Operational Management Plan*; though for the Russell Road Buffer Lake outflow, nutrient levels were outside of the limits, though significantly closer than last year. It is unknown to what extent the supplementation waters contribute towards the total recharge of the lake.

The Total Phosphorous level recorded at Thomsons Lake itself in spring 2016 from a combined sample from three sites, was 60 µg/L, which is higher than the 2015 record (40 µg/L) and higher than the calculated average of 57 µg/L since supplementation commenced in 2004. The sample was collected a day or two prior to the additional drainage water being received from the two buffer lakes. The calculated average is still significantly lower than the consistently high levels recorded at Thomsons Lake during the late 1990s and early 2000s, prior to the commencement of the water supplementation program.

Although better than last year, the nutrient load of the Russell Road Buffer Lake outflow into Thomsons Lake is still greater than the target range. The *Jandakot Wetland Monitoring: Annual Report 2016* (Bennelongia 2017) notes that total N and total P both breach relevant trigger values and Total P has doubled between 2014 and 2016 (from 30 µg/L to 60 µg/L).

It is recommended that the department continue to pursue its enquiries with the Water Corporation with respect to the possibility of supplementing Thomsons Lake only from the Bartram Road Buffer Lakes outflow, at least until such time as the Russell Road Buffer Lake outflow shows some significant improvement in water quality. The potential loss of flow volume into Thomsons Lake would have to be weighed up against the benefit of improved water quality however. During the 93 day water supplementation period for 2016, Russell Road Buffer Lake made up a substantial portion of the flow into Thomsons Lake (approximately 42%).

In order to reduce the amount of nutrient entering Thomsons Lake it is recommended that the Water Corporation and the City of Cockburn be encouraged to implement best practice surface water (stormwater) management where possible. This requires the establishment of more biofiltration systems or retrofitting existing stormwater systems, according to the Department of Water's *Stormwater Management Manual for WA* (2004-2007).

Macroinvertebrate diversity

The total number of macroinvertebrate families recorded in Thomsons Lake during spring 2016 was 37, which is the second highest recorded value since 1996. This may be a reflection of increased sampling or processing efficiency. The supplementation program at Thomsons Lake appears beneficial for macroinvertebrate diversity but ongoing monitoring is required to ensure that water chemistry parameters are not affected and that water levels are sufficient to maintain ecological benefits.

The *Jandakot Wetland Monitoring: Annual Report 2016* (Bennelongia 2017) identified that threats to the conservation values of Thomsons Lake include declining water levels as a result of groundwater abstraction and reducing rainfall; the use of pesticides to control mosquitos and non–biting midges; increasing urbanisation of the catchments leading to nitrification; and the loss of natural habitat (open water and mudflats) because of invasion by introduced bulrushes.

Waterbird observations

Between December 2016 and February 2017, 185 cygnets were found along the vermin-proof fence, which were then released through the fence into Kogolup Lake. This confirms that the lake levels and inundation period were sufficient to allow a successful breeding season; however, many cygnets had not matured enough to fly over the surrounding fence before water levels became unacceptably low. There were no other waterbird counts at Thomsons Lake in 2016.

Analysis of assessment criteria for the 2016 program

The following addresses the four assessment criteria listed in the *Operational Management Plan*.

1. The monitoring undertaken indicated that there were no appreciable detrimental impacts on Thomsons Lake that could be directly attributed to water supplementation. Monitoring and evaluation of water quality/quantity and macroinvertebrate numbers should continue to occur; the data will be used to assess the system against the Ramsar Limits of Acceptable Change on a biennial basis. Ongoing monitoring of waterbird numbers is required; there has been no available data since 2010.

2. All observations indicate that nutrient concentration guidelines listed for the Bartram Road Buffer Lakes outflow in the *Operational Management Plan* are still appropriate (maximum Total Phosphorous levels of 300 µg/L). However the Russell Road Buffer Lake has higher levels of nutrients and pollutants and needs to be improved or not included in supplementation waters for the long term. The 2015 assessment against Limits of Acceptable Change showed that Total Nitrogen levels in Thomsons Lake are more of a problem than Total Phosphorus so consideration should be given to allocation of TN concentration guidelines for the outflow of both buffer lakes.

3. The extent of the nominal supplementation period from 15 July to 15 September each year is still considered appropriate and should remain unchanged for 2017, subject to there being adequate rainfall prior to commencement, and sufficient winter rains during supplementation. Discharge volumes and water quality should continue to be monitored and reviewed in the future to determine whether changes are required to the supplementation period, and postponing the commencement of the program to allow for the first flush of nutrients should be implemented as required. Where high rainfall is experienced early in the season, consideration should be given towards commencing the supplementation program earlier.

4. Given the data collected on water levels, water quality and macroinvertebrate diversity, it is recommended that supplementation continue in 2017. This should ensure a longer period of

inundation which provides ecological benefits such as improving the breeding success of swans. Nevertheless, the outflow from Russell Road Buffer Lake is a continuing cause for concern. Steps should be taken to encourage the Water Corporation to find some means of improving outfall water quality (using best practice of stormwater management i.e. biofiltration where possible and guidance produced by the Department of Water and Environmental Regulation) or to devise a mechanism whereby supplementation can occur from the Bartram Road Buffer Lakes only. The City of Cockburn should be encouraged to implement best practice stormwater management and consider retrofitting stormwater systems where appropriate within the catchment.

In implementing water supplementation at Thomsons Lake in the future, the Regional Parks Unit will continue to liaise with staff from the department's Biodiversity and Conservation Science as required.

REFERENCES

ANZECC and ARMCANZ (2000). *National water quality management strategy* Paper No. 4: *Australian and New Zealand guidelines for fresh and marine water quality*. Australian & New Zealand Environment & Conservation Council, Agriculture & Resource Management Council of Australia & New Zealand, Canberra.

Bennelongia Environmental Consultants 2015. *Jandakot Wetland Monitoring: Annual Report 2015* Final Report to the Department of Water, May 2016.

Bennelongia Environmental Consultants 2016. *Jandakot Wetland Monitoring: Annual Report 2016* Final Report to the Department of Water, March 2017.

Bureau of Meteorology 2018. Annual Climate Summary for Perth in 2016
http://www.bom.gov.au/climate/current/annual/wa/archive/2016.perth.shtml

Department of Premier and Cabinet 2015. *Perth and Peel Green Growth Plan for 3.5 million. Draft EPBC Act Strategic Impact Assessment Report Appendix D – Ramsar Condition Statements*.

Dooley B. and Jackson T. 2004. *Water Supplementation Operational Management Plan for Thomsons Lake Nature Reserve July 2004*. Department of Environment and Conservation.

Maher K. and Davis J. 2009. (Murdoch University) *Ecological Character Description for the Forrestdale and Thomsons Lakes Ramsar Site* 2009. A report to the Department of Environment and Conservation. June 2009.

Sampey A., Judd S. and Horwitz P. (Department of Water/Edith Cowan University) 2014. *Annual Report for the Environmental Monitoring and Investigating for the Gnangara and Jandakot Mounds – Macroinvetebrate and Water Quality Wetland Monitoring for Spring 2013.* Final Report to the Department of Water, May 2014.

Strehlow K., Davis J. and Sim L. (Department of Water/Murdoch University) 2013. *Biomonitoring of Selected Jandakot Wetlands (Macroinvertebrates) for Jandakot Groundwater Scheme Stage 2. Final Report (1996-2012)*.

Water Corporation 2017. Raw Water Quality, Flow Data and Water Level Measurements for 2016.