Lake Burley Griffin water quality: Health standards, protocols for lake closure and outcomes.

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1. Introduction

On 27 May 2011 the Minister for the Environment and Sustainable Development, directed the Commissioner for Sustainability and the Environment, to undertake an investigation into the state of the water courses and catchments for Lake Burley Griffin. This was initiated in response to the closures of the Lake in recent years for recreational activity, due to safety risks through pollution by faecal bacteria and toxic cyanobacteria.

A reference group was established and is providing advice to the Commissioner on issues associated with the investigation. The reference group is being supported by an advisory group of government and corporate representatives.

The present paper was commissioned to provide the Commissioner with advice which includes the following:

- a comparative assessment of the historical and current health standards and protocols for lake closure with respect to water quality within Lake Burley Griffin with consideration of environmental flows associated with the Lake; and
- recommendations for the short term and the longer term.

2. Context for the investigation

In the past eight years there have been a number of incidents where faecal bacterial or cyanobacterial (blue-green algal) indicator organisms were at extremely high concentrations in the various recreational water bodies in the ACT. As a consequence the lakes have been intermittently closed for recreational use.

The high faecal bacterial indicator counts in Lake Burley Griffin have been attributed to sewerage spills from the Queanbeyan Sewage Treatment Plant (STP), stormwater runoff from the urban area and the possible free growth of a capsulated strain of *E. coli*. High concentrations of cyanobacteria in Lake Burley Griffin and the Canberra urban lakes can be attributed to high nutrient concentrations in runoff after rain, warm water with anoxic lower layers, and low flushing of the lakes through drought.

During the drought the reduced flows into the lakes virtually stopped the flushing of the lakes. At times the only inflow into Lake Burley Griffin was derived from the discharge from the Queanbeyan STP. The reduced flows, along with warm summers and stable conditions during the drought period, lead to cyanobacterial numbers increasing steadily over the summer seasons, reaching peaks in the summers of 2008, 2009 and 2010. During the summer of 2010 the Lake experienced the worst cyanobacterial bloom on record and as a result was closed for an extended period of time due to the health risks to recreational users.

3. The development of the *ACT Guidelines for Recreational Water Quality*, and their implementation for safe recreational use of Lake Burley Griffin

The National Health and Medical Research Council (NHMRC) is the organisation that develops national guidelines in Australia for recreational water quality. The national guidelines are not mandatory and have been developed as a tool for State and Territory governments to develop guidelines for local conditions and circumstances. The aim of the guidelines is to encourage the adoption of a nationally harmonised approach for the management of the quality of waters for recreation. The NHMRC has developed a number of recreational guidelines over the last two decades.

Australian Guidelines for Recreational Water Use (1990)

These guidelines were produced by the NHMRC and released in 1990. The guidelines were very limited in the information provided, but did cover issues such as microbial indicators, pH, temperature, plant nutrients, water flows, dangerous objects, clarity, toxic substances, odour, appearance and floatable matter and harmful organisms.

The recreational activities were divided into the water activities with primary and secondary water contact and passive recreational use.

There were no guidelines or advice regarding cyanobacteria in recreational water bodies.

The faecal contamination indicator was the main criterion in determining if the water quality was suitable for swimming and faecal coliforms were the indicator organism. The guideline stated a "median value not exceeding 150 faecal coliforms per 100mL for a minimum of 5 samples taken at regular intervals not exceeding 1 month with 4 out of 5 samples containing less than 600 faecal coliforms per 100mL."

ACT Blue-Green Algae Action Plan (1999)

The Blue-green Algae Action Plan was a section in the Water Pollution Protection Policy ACT, 1999. This guideline for blue-green algae (cyanobacteria) concentration was based on the blue-green algae guideline numbers in Chapter 5 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

This action plan provided the guideline for lake closures on the basis of cyanobacterial counts in the recreational water bodies in the ACT, before the current ACT Guidelines for Recreational Water Quality (2010) were developed.

The guideline was for recreational areas of the lakes to be closed when blue-green algal (cyanobacterial) cell numbers exceeded 20,000 cells per mL.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000)

Chapter 5 of this document sets the guidelines for recreational water quality and aesthetics. It is essentially an expansion of the NHMRC 1990 Australian guidelines for recreational use of water, with additional information on nuisance organisms. This section stipulates, "Direct contact activities should be discouraged if algal levels of 15,000 – 20,000 cells/mL are present, depending upon the algal species". It also describes the health issues associated with contact with blue-green algae (cyanobacteria).

***Guidelines for safe recreational water environments- volume 1: Coastal and fresh waters* (World Health Organization 2003)**

The World Health Organization (WHO) 2003 Guidelines adopted a preventative risk management approach to the review and assessment of the health hazards encountered during recreational use of water environments. The issues addressed include drowning and injury prevention, sun, heat and cold, faecal pollution, microorganisms, chemical and physical agents, dangerous aquatic organisms monitoring and blue-green algae.

The algal section of the WHO guideline recommends posting advisory signs when counts of 20,000 blue-green algae cells/mL or more have been found in the affected water. This advisory level was not adopted in the current NHMRC 2008 guidelines.

***Guidelines for Managing Risks in Recreational Water* (NHMRC 2008)**

The 2008 Australian guidelines produced by the NHMRC are based on the WHO recreational guidelines with the addition of the most recent information and research available.

The 2008 guidelines were a much more comprehensive document than the 1990 guidelines and opted for a preventative risk management approach for the management of recreational waters. These guidelines essentially followed the WHO guidelines. The NHMRC guidelines focus on developing an understanding of all potential influences on a recreational water body, through local assessment and management of hazards and of factors that may lead to hazards. A key aspect of the preventative approach is the development of monitoring programs that can provide a real-time indication of water quality.

ACT Guidelines for Recreational Water Quality (2010)

The *ACT Guidelines for Recreational Water Quality (2010)* focus on the microbiological and cyanobacterial issues in the ACT recreational water bodies.

The ACT Guidelines for recreational water quality have followed the NHMRC's lead in regard to blue-green algae cell numbers but have modified the alert levels to suite the local conditions and lake users groups activities. The numbers refer to *Microcystis aeruginosa* or *Anabaena circinalis* which are most commonly occurring planktonic (free floating) toxic cyanobacteria in the Lake. Where cyanobacteria of a different

size to *M. aeruginosa* are identified eg *Aphanocapsa* the biovolume, expressed as mm^3/L, should be referenced as well as the cell count.

The ACT guidelines also incorporate the WHO (2003) advisory warnings and signage for 20,000 cells/mL of cyanobacteria. This has been included for the protection of individuals that suffer from the irritative or allergenic effects of cyanobacterial compounds and is based on Australian studies. The NHMRC 2008 guidelines acknowledged the "irritative or allergic effect" but also considered the Pilotto (2004) study and concluded that

> "The interpretation derived from the study is that these mild skin irritative effects, which are readily resolved without medical treatment, do not warrant consideration in the setting of a quantitative guideline for recreational exposure".

However as 12% of the study group did suffer from some effects, it was considered that one in eight people, in contact with the contaminated water, may be subjected to an irritative or allergic effect and this would not be acceptable to the ACT public. Therefore the WHO advisory sign policy was adopted in the new ACT guidelines when the counts reached 20,000 cells/mL

The ACT guidelines have also included an action plan for the benthic (filamentous, attached to plants) cyanobacterium *Tychonema*. This organism tends to be a problem in the winter months and has killed (poisoned) a number of dogs and made numerous other dogs violently ill. This organism also has the potential to affect individuals that wade or work in the shallow water along the edge of the lake. There is anecdotal evidence of people working in the lake that have been affected by this organism with vomiting and diarrhoea.

A literature search failed to identify any guidelines for this organism, so an action plan was developed based on visual inspections (See page 6 of the ACT guidelines). In summary, if no growth is observed, maintain routine visual monitoring. If benthic growth is observed, indicate the risk on the warning signs and if obvious growth or floating mats are observed, close the area to primary contact recreation.

The faecal bacteriological indicator, intestinal enterococci, was implemented in line with the NHMRC guidelines. The guideline value of >200 CFU/100mL was adopted based on the NHMRC guidelines, where above this number gasterointestinal illness risk was between 5 -10 % for a single exposure and acute febrile respiratory illness risk was between 1.9 – 3.9%. A copy of the current guidelines is attached.

4. Legislation for Recreational Water Quality in the ACT

ACT is unique and differs from other States and Territories in that the ACT has legislation that allows enforcement of restrictions on local water bodies. Other States and Territories are not able to enforce the restrictions recommended by the managing authority so they provide advice, which is generally accepted by the local authorities and the public.

Before the *ACT Guidelines for Recreational Water Quality (2010)* were developed the management of blue-green algae and bacterial indicator numbers in ACT recreational water relied on two separate documents: Schedule 2 – Blue-green algae action plan of the Water Pollution Environment Protection Plan (1990) for algal numbers and the *Australian Guidelines for Recreational Water Use* (NHMRC 1990) for bacterial indicator numbers.

The actual guideline numbers for lake closures for both bacterial indicators and blue-green algae in the new ACT guidelines were increased substantially from the old guidelines to the new guidelines, therefore accepting an increased level of risk. The cyanobacterial (blue-green algal) numbers for lake closure to body contact water sports have been increased from 20,000 in schedule 2 to 50,000 cells/mL in the current guidelines. A similar increase has occurred in the faecal bacterial indictors, in which there has been an increase from 35 cfu/100mL enterococci with the old guideline, to 200 cfu/100mL in the new guideline. (The 1990 NHMRC guideline used 150 faecal coliforms as the indicator, however it was accepted that this is equivalent to 33 enterococci/100mL. The ANZECC guideline stated 150 faecal coliforms were equivalent to 35 enterococci/100mL). It is apparent that there would have been more recent closures of recreational areas in the lakes with the old guidelines, if the new less-stringent guidelines had not been implemented.

3.5 Guidelines

The table below outlines the microbial water quality assessment criteria using intestinal enterococci as the indicator organism.

Alert Level	Count cfu/100mL	Monitoring Requirements	Typical Actions
Open	≤ 200	Continue weekly sampling	Health/NCA Maintain routine monitoring - no additional action is required.
Closed	>200	Initial sample Repeat sample	Health/NCA Take another sample as soon as practical. The site remains open. If repeat sample ≤200 cfu/100mL; - The site remains open & maintain routine monitoring. If repeat sample >200 cfu/100mL; – Inform TAMS & public of the health risk. – Advise public that water, or part thereof, is closed for primary contact use. – Undertake a sanitary survey & identify sources of contamination if considered necessary. – Take another sample as soon as practical. – Change warning signs

2.7 Blue-Green Algae Action Plan

Alert level	Indicative *Microcystis aeruginosa* algae cells/ml*	Biovolume equivalent*	Monitoring requirements	Typical actions (NCA or EPA)
Low	<5,000	<0.4 mm^3/L.	Weekly visual inspections.	NCA/EPA Maintain routine monitoring.
Medium	≥5, 000 to <50,000 >20,000	≥0.4 to < 4 mm^3/L >1.6 mm^3/L	Increase to twice weekly visual inspections & take water samples as required.	NCA/EPA † Increase visual inspections and sampling for algal counts. If > 20,000 cells/mL, advise ACT Health, and change warning signs to indicate increased risks for skin irritations, gastrointestinal illness. Issue Media release to public and lake users.
High	≥50,000 to ≤125, 000	≥4 mm^3/L to <10 mm^3/L	Maintain twice weekly visual inspections and take water samples as required.	NCA/EPA † Maintain increased visual inspections. Regular algal counts. Advise ACT Health. Advise public that water, or part thereof, is closed for primary contact use. Issue Media release to public and lake users to indicate site closed from primary contact use. Change warning signs to indicate site closed for primary contact use.
Extreme	≥125,000 or scums are consistently present** (40,000 cells/mL *Anabaena* sp.)	≥10 mm^3/L	Maintain twice weekly visual inspections and take water samples as required.	NCA/EPA † Advise ACT Health. Advise public that contact with water, or part thereof, poses an increased level of risk for secondary contact users. Issue Media release to public and recreational users.

* Indicative numbers for *Microcystis aeruginosa*. If other types of blue-green are present the biovolume should be referenced.

** Persistent scums are scums that are seen at some time each day at the recreational site.

† ACT Health may be contacted for advice on the cell numbers/biovolume and alert levels.

2.8 Decreasing Alert Levels over Time

Reductions in alert levels from a higher to a lower level should not occur until the results from two consecutive samples have recorded lower counts for the alert level and anticipated environmental conditions (e.g. temperature etc) are not conducive to facilitating a rapid increase in blue-green algae populations.

The 2010 ACT guidelines were developed in consultation with the National Capital Authority, the Environment Protection and Water Regulation, and Territory and Municipal Services with a targeted public consultation process involving all major lake user groups.

5. Faecal microbial pathogens in Lake Burley Griffin

Ingestion of water containing faecal pathogenic organisms gives rise to many enteric disorders, largely brief and self-limiting, but occasionally severe.

To prevent sickness occurring among people exposed to water, the safe limits for faecal contamination in both recreational water (as discussed earlier) and drinking water, have been determined by the National Health and Medical Research Council and incorporated into the ACT Guidelines. As a consequence of the difficulty of measurement in water of viruses or protozoa and the diversity of bacteria in natural waters, the commonly measured organisms are faecal coliforms (*Escherichia coli* strains), and intestinal enterococci, both of which occur abundantly in faecal material from people and animals. These are used as marker organisms for faecal pollution and thus relate to the extent of contamination of the water, though they are not necessarily actual pathogens.

Hence monitoring of Lake Burley Griffin and the Molonglo River for these organisms indicates the potential safety (or otherwise) for recreational use of the lake and river. The current ACT Guidelines for Recreational Water Quality use enterococcal concentration as the marker organism as described above, with lake access open when the organisms are below 200 colony forming units/100mL of water, and closed for primary body contact use when the concentrations are higher. This warns of the danger to health of use for swimming, water-skiing, diving and windsurfing under these conditions. At very high concentrations of enterococci indicating extensive faecal pollution presenting a substantial health risk, the lakes are closed for all users. During the last summer (2010/2011) enterococci peaked in East Basin of Lake Burley Griffin at 12,000 colony forming units/100mL in December, and were over 200 in six consecutive samples. Weston Park East and Black Mountain Beach, both popular recreation areas, exceeded the 200 concentration eleven times.
Excessive concentrations of faecal organisms in the water resulted in the whole lake being closed from late November to mid December 2010 and mid January to mid March 2011 for primary contact water sports due to both enterococci and cyanobacteria.

The lake was closed to all users in the first week of December 2010, after the heavy rainfall. This total closure was due to a combination of hazard from floating debris and trees and clear evidence of faecal contamination of the lake water. This late November/December bacterial contamination of the Molonglo River and Lake Burley Griffin was due to a number of separate components. Heavy rain (a one in 20 years storm event) resulted in partially treated sewage overflow from a broken retention wall at Queanbeyan STP, posing a significant risk to human health. The floodwater entering Lake Burley Griffin also carried many dead willow trees from the Molonglo River bank, making use of the lake dangerous for recreation. After clearing the majority of the floating debris the lake was re-opened for secondary contact recreation. The water-ski reach of the Molonglo River is still shut due to floating debris and sandbanks at the time of writing, sixteen months after the event. It can be expected that urban stormwater, including material from gross pollution traps, also carried a substantial load of faecal microorganisms of animal origin into the lake. An excessive count of enterococci in Lake Burley Griffin also occurred after the Sullivan's Creek gross pollution trap was cleaned.

The previous year (the summer of 2009/10) enterococcus counts reached 7,800 in February in East Basin, and were above the primary contact guideline (200) for most of the summer. Similarly for most of the 2008/09 summer the counts exceeded the primary contact limit for faecal coliforms, which were the organisms measured upto 2009.

Wet summers exacerbate this problem at the time of maximum recreational use, due to contaminated urban runoff.

In general, the microbial contamination of Lake Burley Griffin in summer presents a potential health threat to lake users, and requires remediation if the lake is to be used for year-round recreation by primary body-contact water sports. This particularly affects swimming, including triathlons, water skiing, and wind-surfing, all major recreational uses of the river and lake.

6. Cyanobacteria

Water quality problems from cyanobacteria (blue-green algae) in Australia are not new to human or to livestock health.

Toxic cyanobacteria first came to the attention of Australian health officers in Adelaide in the 1800's, when numerous domestic livestock died as a result of drinking water contaminated by *Nodularia* on the shores of Lake Alexandrina. The South Australian public analyst, who looked at the dead animals and sampled the water, investigated this early poisoning event. He dosed a calf with the green scum collected from the edge of the lake, which died (Francis, 1878). The organism is a common cyanobacterial species in estuarine lakes in Australia, and has caused extensive problems in the East Gippsland lakes. Since that time many incidences of livestock deaths have been reported worldwide from cyanobacterial poisoning, in some cases with mortalities in the thousands of animals.

The most frequently offending species of toxic cyanobacteria in Australia are *Microcystis aeruginosa* and *Anabaena circinalis.* The first of these organisms produces a cyclic peptide causing liver damage if swallowed and pneumonia if inhaled. This organism has caused documented health injury to canoeists, who were exposed to the toxicity by carrying out Eskimo rolls, and to swimmers in contaminated lakes. The most severe effects were from inhalation of the organisms, causing pneumonia (Falconer, 2005).

The second organism, *Anabaena,* produces neurotoxic alkaloids related to the shellfish poison saxitoxin (which results in paralytic shellfish poisoning) and can cause muscular spasms if swallowed. This was suggested by the Coroner as the cause of death of a teenager who swam in a scum of the organisms in a golf course lake in the USA.

The many deaths of cattle and sheep drinking from the Darling River in 1991 were caused by poisonous *Anabaena* (Falconer, 2005). There have been numerous reports of allergic responses in people swimming in lakes contaminated with this cyanobacterium, and repeated exposure exacerbates the effect (Falconer, 2005).

Both of these organisms live suspended in the water (planktonic species), grow abundantly when the nutrient supply is sufficient, and proliferate during the summer months when the water temperature rises. On calm days they rise to the surface and cause concentrated scums on the shoreline. These present an enhanced risk of exposure to bathers.

In cooler conditions other species of cyanobacteria grow on aquatic plants in lakes, as a fine fur on the leaves (benthic species). These organisms are also neurotoxic and dogs appear to be particularly susceptible. Dog deaths have occurred here of animals paddling or swimming in both Lake Burley Griffin and Lake Ginninderra in the winter, with typical symptoms of nerve toxicity.

Since these hazards to animal and human health occur worldwide, the World Health Organisation set up an expert group to evaluate the risks from contamination of drinking water and through recreational exposure (Chorus and Bartram, 1999). The risks specifically associated with recreational exposure were further examined by Chorus, Falconer, et al. (2000) for the World Health Organisation.

The predominant cyanobacteria in the waters of the Molonglo River and Lake Burley Griffin in the summer are *Microcystis* and *Anabaena*, which both provide a risk to human health through recreational exposure. The extent of the risk is determined by the overall toxicity, which increases with the concentration of cells in the water. As actual toxicity measurement is slow and expensive, jurisdictions worldwide have adopted a cyanobacterial cell count as the most effective measure of risk. In Canberra the Environment Protection Authority and the National Capital Authority both monitor cyanobacterial cell counts and species in the summer months at a range of sites. In winter there is visual monitoring of cyanobacteria in the water and that growing on aquatic vegetation.

When the cell counts reach designated levels in the lakes showing potential risk, the ACT Guidelines come into force, the monitoring is increased and the river and lakes are closed for body contact water sports, but remain open for rowing, boating and fishing. If the cyanobacteria reach higher concentrations (extreme alert), such that accidental exposure from indirect contact through splashing during canoeing or rowing are a risk to health, then the lake users are warned that secondary body contact with the water may result in adverse health effects. The ACT guidelines set out the details of precautions, including showering, and users need to follow the advice.

An example of the media release in January 2011 is below.

Lake Burley Griffin Blue-Green Algae Alerts

PRINT

27 January 2011

Extreme Blue-Green Algae Alert for Black Mountain Beach and Weston Park

Black Mountain Beach and Weston Park (East and West) in Lake Burley Griffin are currently closed to primary contact recreation due to high levels of blue-green algae.

At present, the blue-green algae levels are at the Extreme Alert Level. The water is closed to primary contact recreation as exposure to this level of blue-green algae carries an increased risk of adverse health effects.

Primary contact recreation means recreation that involves whole-body water contact or submersion of the head. Examples include swimming, diving and windsurfing.

Secondary contact recreation (such as rowing, fishing, boating and canoeing) will still be permitted, noting ACT Health's advice below.

ACT Health advice is that:

- Symptoms of blue-green algae exposure may include skin/mucosa irritation, flu-like symptoms, and gastrointestinal illness
- There is an increased risk of adverse health effects from water exposure for secondary contact recreation
- People should not engage in secondary contact recreation unless:
    - *They are experienced;*
    - *They are informed of the algal risks and what to do if contact occurs;*
    - *They do not engage in primary contact during the recreation; and*
    - *Showering facilities, with suitable water, are available for washing after the recreation*
- Water users should shower after water contact;
- Event organisers should ensure that participants are aware of the blue-green algae alert level, associated exposure risks and provide adequate showering facilities for after events;
- Water users should look for algae warning signs indicating the current alert level at major water entry points as algal levels can change quickly depending on the weather and water nutrient levels.

Medium Blue-Green Algae Alert for West Basin

The National Capital Authority has also issued a Medium Alert Level for blue-green algae in West Basin. West Basin will remain open to all users, noting ACT Health's advice below.

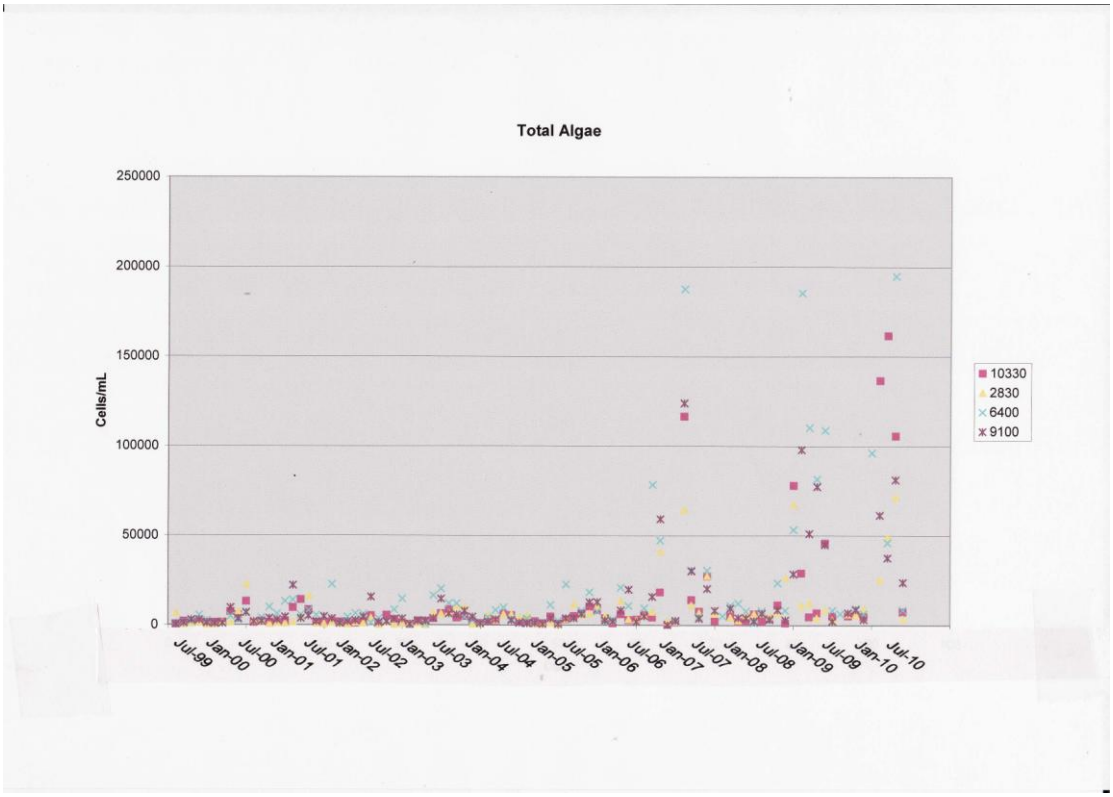
ACT Health advice is that:

- Although the lake area remains open to all users, some susceptible individuals exposed to this water may experience skin irritations, hay fever-like symptoms or flu-like symptoms after contact with affected water
- Water users should shower after water contact and avoid submersion
- Water users should look for algae warning signs indicating the current alert level at major water entry points as conditions can change quickly depending on the weather and water nutrient levels

Weekly lake updates, information on water quality and the 'ACT Guidelines for Recreational Water Quality' are available here.

Over the last decade there appears to have been a considerable increase in the summer cell counts of toxic cyanobacteria in Lake Burley Griffin. From 1999 to 2002 the peak cyanobacterial counts in Lake Burley Griffin were about 10,000 cells/mL or lower in the summer, presenting a low risk. By January 2007 the cyanobacterial concentration reached 60,000 to 80,000 cells per mL of lake water at some sites (particularly beaches), just reaching the 'High Alert' (high risk) level. From January to May in 2009 some sites reached 150,000 cells/mL, well into the extreme alert category. Similar concentrations of cells were seen in 2010, with some beach sites accumulating cyanobacteria at above 300,000 cells/mL. Under the earlier ACT guidelines secondary contact water sports, such as rowing and sailing, would also have been prohibited at this level of cyanobacterial contamination.

These cyanobacterial scums are particularly hazardous, due to the frequent high concentrations of toxins present. Most livestock deaths have been due to shoreline scums of cyanobacteria, with animals drinking.



Data from NCA monitoring report March, 2011

Colour points represent different monitoring sites. The high alert level is above 50,000 cells/mL (Log 4.7) and extreme alert level over 125,000 cells/mL (Log 5.06) for cyanobacteria, which are the predominant organisms during cyanobacterial water blooms.

These concentrations of cyanobacteria resulted in lake closures for body contact water sports during the summer months over the last four years. Beach concentrations can be greatly higher than those in free water, due to surface scums moving down-wind

onto beaches. The highest measured was 570,000 cells/mL. greatly exceeding the extreme alert level of 125,000 in the current ACT Guidelines for Recreational Water Quality.

The Canberra urban lakes have been closed or warning signs erected due to cyanobacteria at high to extreme concentrations on nine occasions during the last four years, as listed below.

Alert Dates

Lake Tuggeranong
27 November 2007 – 10 January 2008 High Alert

12 March -4 April 2008 High Alert

3-5 February 2009 Medium
5 February - 18 May 2009 High Alert
18 May – 19 August 2009 Medium

28 January – 15 April 2010 Extreme Alert
15 April – 27 May 2010 Medium

10 February – 11 March 2011 High Alert
11 March – 1 April 2011 Extreme Alert
1 April – 16 June 2011 Lake Closed

Lake Ginninderra
3–11 February 2009 Medium
11 February – 18 May 2009 High Alert
18 May – 19 August 2009 Medium

22 April – 10 June 2010 Medium

Molonglo Ski Area
3-11 February 2009 Medium
11 February – 18 June 2009 High Alert
18 June – 19 August 2009 Medium

14-21 January 2010 Medium
21-28 January 2010 Extreme
28 January – 25 February 2010 High Alert

8 April – 13 May 2010 Medium

These cyanobacterial alert concentrations reflect similar contamination in Lake Burley Griffin during summer.

7. Conclusion and recommendations

It can be concluded that high to extreme concentrations of potentially toxic cyanobacteria, and high concentrations of faecal microorganisms, occur at intervals in Lake Burley Griffin. The lake has particular areas where the health risk is greatest, generally those shallow areas used as swimming beaches which accumulate scums. The 2010 ACT Guidelines provide detailed recommendations on lake closure, and precautions to be taken by recreational users.

Recommendations

Since the changes in the Guidelines for recreational use of the Canberra Lakes in 2010, it is particularly important to monitor any observed adverse health impacts to lake users of either bacterial or cyanobacterial contamination of the lakes. These include gastrointestinal illness, skin allergies, respiratory difficulties, eye inflammation or flu-like symptoms following water sports on or in the lakes.
Similarly any health problems with domestic pets following water contact should be reported.

References

ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand, Australia.

Blue-green Algae Action Plan (1999) Page 54,10.2 Schedule 2, Water Pollution Environment Protection Policy, ACT Government.

Chorus,I and Bartram, J. (1999) Toxic Cyanobacteria in Water, E.& F. Spon, London (on behalf of WHO).

Chorus, I, Falconer, I.R., et al. Health risks caused by freshwater cyanobacteria in recreational water. Journal of Toxicology and Environmental Health part B, 3, 323-347.

Falconer, I.R. (2005) Cyanobacterial Toxins of Drinking Water Supplies. CRC Press, New York.

Francis, G. (1878) Poisonous Australian Lake, Nature, 18(2);11-12.

NHMRC (1990) *Australian Guidelines for Recreational Water Use.* NHMRC, Australian Government Publishing Service, Canberra.

NHMRC (2008) *Guidelines for Managing Risks in Recreational Water*. NHMRC, Australian Government Publishing Service, Canberra.

Pilotto LS, Hobson P, Burch M, Ranmuthugala G, Weightman W and Attewell R (2004). Acute skin irritant effects of cyanobacteria (blue-green algae) in healthy volunteers. *Australian and New Zealand Journal of Public Health* 28:220-224.

Pilotto LS, Douglas RM, Burch MD, Cameron S, Beers M, Rouch GR, Robinson P, Kirk M, Cowie CT, Hardiman S, Moore C and Attewell RG (1977). Health effects of exposure to cyanobacteria (blue-green algae) due to recreational water-related activities. *Australian and New Zealand Journal of Public Health* 21:562-566.

WHO (2003) *Guidelines for Safe Recreational Water Environments. Volume 1. Coastal and Fresh Waters.* WHO, Geneva.