HPA Guidance on the Management of Cyanobacteria (Blue-Green Algae) in Inland Recreational Waters

1. Introduction

Cyanobacteria or blue-green algae are small unicellular photosynthetic bacteria. They live in fresh, brackish and marine water and are natural inhabitants of inland fresh water bodies including lakes, rivers and reservoirs. They proliferate in shallow, warm, slow-moving or still water and while they are individually too small to be seen by the naked eye they can form large visible colonies called algal blooms. These blooms can range in colour from blue-green to red depending on the prevalent species. Cyanobacteria have been linked to human and animal illness across the world including the UK, Europe, North and South America and Australia.

This guidance discusses the health risks presented by cyanobacteria in freshwater, and has been prepared to assist health professionals in England and Wales in addressing the potential public health risks associated with exposure to cyanobacteria in inland recreational waters. Future guidance on marine algae is planned.

2. Cyanobacteria bloom and scum formation

Under favourable conditions cyanobacteria can rapidly proliferate forming dense blooms and surface scums which accumulate at or near the water surface, turning the water cloudy. Blooms can form quickly on a calm day. These blooms can form surface scums in calm conditions which can be blown onto the downwind (lee) shore, accumulating as a result of wind action. Blooms can disperse rapidly due to wind and wave action. Cyanobacteria can also occur as thick mats which grow on the bottom of shallow water bodies [1, 2]. Not all bloom forming cyanobacteria form a surface scum on the water (e.g. Cylindrospermopsis raciborskii which forms dense layers beneath the water surface)

Typically bloom formation follows a predictable cycle developing in late summer/early autumn. Conditions conducive to bloom formation are dependent on water temperature, light, eutrophication[1], water flow (still or stagnant waters with weak currents and flows are more favourable) and weather conditions (typically warm and stable). Some water bodies regularly host large populations of cyanobacteria for several months of the year and should be regularly inspected for algal blooms.

Persistence is typically dependent on the cyanobacteria species present, prevailing weather conditions and the lake topography (bloom location). Blooms can persist for weeks or months especially in shallow bays where the potential for dispersion can be limited.

3. Toxicity of cyanobacteria

Cyanobacteria produce a variety of different toxins which can adversely affect human and animal health. Knowledge of species toxicity is limited; however, 45-90% of cyanobacteria blooms are thought to produce cyanotoxins [1]. Specific cyanotoxins and the concentrations produced vary from species to species, with some species having the ability to produce more than one type of cyanotoxin

[1] The enrichment of bodies of fresh water by inorganic plant nutrients (e.g. nitrate, phosphate), that may occur naturally or as the result of human activity (e.g. fertilizer runoff and sewage discharge).

simultaneously [3]. Typical cyanotoxins and examples of producing species are shown in Table 1. Toxicological information of individual toxins is limited. One of the most common cyanobacteria in UK fresh waters is *Microcystis aeruginosa,* which can produce potent hepatotoxins [4].

Usually contained within the cyanobacterial cell, cyanotoxins are typically released on cell death, following which they are rapidly diluted within the water body reducing the risk to health. Most cases of adverse health effects have been associated with exposure to cyanobacteria blooms or scums. Blooms and scums have been shown to increase cyanobacteria cell density and cyanotoxin concentrations by over 1000 fold [3]. Consequently exposure to algal blooms or scum poses the greatest risks to recreational water body users.

Cyanobacterial blooms are typically heterogeneous in nature. More than one toxin producing species may be present. Algal distributions and consequently cyanotoxin types and concentrations can change rapidly in time and space making quantitative assessment of toxins levels within the bloom difficult. The relationship between cell count and cyanotoxin concentration is unclear. It is impossible to ascertain the toxicity of a bloom from appearance.

There have been numerous reports of fatal poisoning of animals following exposure to cyanobacterial toxins. Dogs have died after swimming in contaminated water bodies, with symptoms following exposure including salivation, weakness, staggering, acute respiratory failure and death [3, 4]. There are also numerous reports of death of livestock following the consumption of water contaminated with cyanobacteria.

Table 1. Cyanobacteria toxins, producing species and associated health effects [3, 4]

	Hepatotoxins	**Neurotoxins**	**Lipopolysaccharide (LPS) endotoxins**
Associated health effects	Include: • Enlarged liver • Malaise • Anorexia • Vomiting • Headache • Parasthesia, lip and mouth numbness. • Motor weakness incoordination • Respiratory and muscular paralysis	Include: • Affects nerve transmission at neuromuscular junction *(e.g. saxitoxins)* • Mimic acetylcholine blocking nerve transmission (e.g. anatoxin-a) • Inhibits acetylcholinesterase (e.g. anatoxin-a(S)).	Include: • Gastrointestinal effects • Allergic type response • Irritation of skin & eyes • Irritation of mucous membranes
Example toxins	• Microcystins. Microcystin-LR[2] is considered to be one of the most frequent and most toxic hepatotoxins • Nodularins • Cylindrospermopsin	• Anatoxin-a considered most likely in UK waters • Homoanatoxin-a • Anatoxin-a(s) • Saxitoxin • Neosaxitoxin.	Varies between strains of species
Producing species	Produced by several species including: • *Anabaena* • *Microcystis* • *Oscillatoria* • *Nostoc* • *Nodularia* • *Planktothrix*	Produced by several species including: • *Anabaena* • *Aphanizomenon* • *Oscillatoria* • *Phormidium*	Component of outer layers of cyanobacterial cell wall.

[2] LR refers to the amino acids leucine and arginine

The only reported human deaths followed intravenous exposure to cyanotoxins during renal dialysis [3], which occurred in Caruaru, Brazil. Water contaminated with microcystin is thought to have been a major contributing factor in the mass poisoning of dialysis patients. In total, 117 of 136 patients became ill. 100 patients developed acute liver failure, and 50 of these patients subsequently died [3]. Symptoms were consistent with exposure to microcystin exposure and it was estimated that the level of microcystin in water used for dialysis treatment was nearly 20 times the guideline for drinking water (0.001mg/litre for total microcystin, free plus cell bound) set by the World Health Organization (WHO).

When responding to incidents involving blooms of cyanobacteria, until the presence of a toxin or a toxin producing cyanobacteria is confirmed it is prudent to assume cyanotoxins are present and the likelihood of elevated toxin levels increases with bloom density. When responding to cyanobacteria notifications, the Environment Agency (EA), regulators for waterbodies in the UK, consider all cyanobacteria species to be potentially capable of producing toxins [2].

4. Routes of exposure and acute health effects associated with recreational use of water bodies

While there have been few documented cases of human illness attributed to cyanotoxins in the UK, there are reports of acute health effects following recreational exposure to cyanobacterial blooms. Symptoms following recreational use of water bodies are chiefly irritative symptoms following exposure to unknown cyanobacterial substances (lipopolysaccharide endotoxins), however there have been incidences of more severe exposure to high concentrations of cyanotoxins resulting in gastrointestinal symptoms [5], for example in the UK ten soldiers became ill with symptoms including abdominal pains, vomiting, diarrhoea, blistering of the mouth and sore throats, following canoe training in a lake in Staffordshire in 1989 [3]. The potential for long term health effects of cyanotoxins are not fully understood [1].

Symptoms following exposure will be dependent on the cyanotoxins present, the concentration of cyanotoxins, and the route and the duration of human exposure to the cyanotoxins. Potential symptoms during and following water related recreational activities can arise via three exposure routes: dermal/eye contact, ingestion and inhalation. These routes and associated symptoms are shown in Table 2.

Table 2. Exposure routes and associated health effects

Exposure route	Typical symptoms	Key points to consider
Dermal/eye contact	• Skin irritation, rash or dermatitis • Eye irritation and conjunctivitis	Risk increases with exposure time. Bathing suits and wetsuits often aggravate symptoms. Cells become trapped and disrupted beneath material, resulting in close contact for extended period of time.
Ingestion (accidental swallowing)	• Gastro intestinal effects are common, e.g. abdominal pain, nausea, vomiting and diarrhoea. • Respiratory features e.g. sore throat, cough and pneumonia. • Less commonly headache, earache, swollen lips, pyrexia, rhinitis (hay fever like symptoms).	Typical onset 3-5 hours following exposure. Symptoms typically last 2-3 days following exposure.
Inhalation of contaminated water aerosol	• Hay fever/asthma like symptoms. • Respiratory features include sore nose and throat, cough and pneumonia. • Less commonly headache, earache, swollen lips, pyrexia, rhinitis.	Exposure following jet skiing, water skiing and spray inhalation on windy days

Individual sensitivities can vary. Susceptible groups include chronic hepatitis B sufferers and children. Children are at higher risk due to their greater susceptibility and increased likelihood to undertake activities which result in a greater exposure to the cyanotoxins (e.g. playing in waters).

Other potential routes of exposure include consumption of untreated drinking water and the use of untreated water in dialysis. However, these are not considered an issue in the UK where abstraction of water contaminated with cyanotoxins is not permitted. As with marine algal toxins (such as those associated with paralytic shellfish poisoning) cyanotoxins have the potential to accumulate in the food chain, specifically fish and shellfish. The Food Standards Agency (FSA) can provide advice on the safety of fish or shellfish harvested from contaminated water.

To help determine the potential health risks following exposure to cyanobacterial toxins in recreational waters the WHO has developed tiered guidance levels differentiating between the "chiefly irritative symptoms caused by unknown cyanobacterial substances and potentially more serious hazard of exposure to high concentrations of known cyanotoxins, particularly microcystins" (Table 3) [3]. The WHO's pragmatic approach is based on the measurement of algal cell count, rather than toxin levels, due to the limited toxicological information available and potential variation in toxin production and concentration from day to day.

Table 3: WHO guidance levels on risks associated with cyanobacterial blooms [1, 3, 6]

Guidance level or situation	Health risks	Derivation of guidance level	Typical actions
Cyanobacterial scum formation in bathing areas	High risk of adverse health effects • Potential for acute poisoning • Potential for long-term illness • Short-term adverse health outcomes e.g. skin irritations and gastrointestinal illness	• Increased risk of irritant symptoms • Increased potential for toxins to reach toxic levels • Oral animal lethal poisonings • Human illness case histories	• Immediate action to control contact with scum • Possible prohibition of swimming • Possible prohibition of water based activities • Public health follow up • Inform public and relevant authorities
100,000 cyanobacterial cells per ml or 50 μg/L chlorophyll a with dominance of cyanobacteria	Moderate probability of adverse health effects • Potential for long- term illness with some cyanobacterial species • Short-term adverse health outcomes e.g. skin irritations, gastrointestinal illness	• Increased risk of irritant symptoms • Increased potential for toxins to reach toxic levels • Derived from provisional drinking water guideline and data concerning other cyanotoxins • Potential of some frequently occurring cyanobacterial species to form scums	• Intensify surveillance and watch for scums and conditions conducive to scums • Discourage bathing • Further investigate hazard • Post on-site risk advisory signs • Inform relevant authorities
20,000 cyanobacterial cells per ml or 10 μg/L chlorophyll a with dominance of cyanobacteria	Relatively low probability of adverse health effects. • Irritative or allergic effects due to cyanobacterial substances • Short-term adverse health outcomes e.g. skin irritations, gastrointestinal illness	Relatively mild/low probability of adverse health effects • Derived from human bathing epidemiological study • Based on irritation resulting from cyanobacterial substances	• Post on-site risk advisory signs • Inform relevant authorities for further surveillance

5. Responding to a cyanobacteria incident

Following identification of a potential cyanobacteria incident there is a need to confirm the presence of hazardous accumulations of cyanobacteria and assess any potential risks to human health.

Key stages and actions

See Appendix 2: Flow chart of actions to be taken in relation to a potential cyanobacteria incident

i) Notification

The EA become aware of a potential cyanobacteria incident when:

- asked to investigate the presence of a potentially toxic algae in a water body by owner or user, or
- following identification of an algae bloom during routine sampling.

From the EA's perspective an algal incident is defined as: the presence of a high count of algal cells; scum or film on the water or strandline; discoloured waters; excessive growths of algae; decomposing algae; adverse human or animal health problems linked to algae; fish kills involving algae/algal toxins [2].

Following identification of a cyanobacteria event, when the cell count exceeds the warning threshold defined for the species in the EA guidance (*see EA Operational Instruction 907-08*) the EA are responsible for notifying the water body owner, local abstractors and local authority Environmental Health Officers (including Animal Health) [2, 7]. The EA warning thresholds provide an indication for the possibility of bloom formation and the potential for scum formation [7] (*see Appendix 3*).

Defra, FSA, Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and the HPA will be notified when deemed necessary (see *Appendix 1: Agencies and stakeholders roles and responsibilities*) [2].

The HPA (via the local Health Protection Units) may be notified of a cyanobacteria incident by:

- The Environment Agency (EA)
- Local authority
- Water body owner
- Member of the public

ii) Risk Assessment: Public health response to a cyanobacteria incident

A multi-agency approach may be required to co-ordinate the response to a cyanobacteria event, particularly when there are potential public health issues (*see Appendix 1: Agencies and stakeholders roles and responsibilities*).

Most cases of adverse health effects have been associated with exposure to cyanobacteria blooms or scums which increase cell density and toxin levels. The presence of cyanobacteria should not automatically lead to the prohibition of all recreational activities. Action should be determined by the water body use and public health assessment. For example, the risk of exposure to significant levels of toxins is likely to be low if the algal bloom is confined to one area, providing immersion sports do not take place in close proximity to the bloom. In this situation a site may be kept open subject to frequent visual inspection (e.g. for scum formation and conditions conducive to scums, assessment of scum location etc).

The risk assessment should consider the water body's characteristics, its use, the nature and intensity of the bloom, the bloom location, and the type of cyanobacteria present within the bloom and the cell count (*See **Risk Assessment** procedure below*). Table 3 details the WHO guidance levels (corresponding to cell count), potential health risks associated with these levels and typical actions, which support the risk assessment. As can be seen by these guidance levels, the presence of scum with a high cell count may lead to the prohibition of all activities. It is the owner's responsibility (e.g. private owner or local authority in case of public water bodies) to make decisions about closure and whether activities can resume following a cyanobacteria incident [2].

Risk Assessment

The risk assessment must take into account the water body's characteristics, its use, the nature and intensity of the bloom and the type and levels of cyanobacteria present within the bloom [2].

i) Assessment of water body characteristics and use

Based on the following:

- Water body characteristics (type and size of water body)
- Use of water body (see below Table)
- Reported human health effect
- Dead fish notification and animal illness

Identification of risk category based on water body use [6, 8].

Risk Category	Nature and Intensity of Use
High	• Activities involving immersion or appreciable skin contact (e.g. swimming, diving, water skiing, paddling, sail boarding. Canoeing if submerging. • High risk of accidental ingestion or inhalation of cyanobacterial material or toxins e.g. water skiing
Medium	• Appreciable skin contact with blooms unlikely e.g. sailing, canoeing / rowing / angling. • Risk of accidental ingestion of cyanobacterial material or toxins is small
Low	• Non-contact activities, e.g. angling, pleasure cruising

ii) Assessment of nature and intensity of bloom

Based on the following:

- Previous history of algal blooms (frequency of occurrence, duration and magnitude). Blooms may follow an annual cycle.
- Presence and scale of bloom or scum:
  - (i) No algae present
  - (ii) Algae present but no bloom or scum
  - (iii) Sporadic blooms evident in water
  - (iv) Prominent blooms
  - (v) Scum on surface or shoreline.
- Bloom/scum location
- Scum typically concentrates downwind on the lee shore: prevailing wind direction should be considered.

iii) Cyanobacteria characterisation

- Confirmation of presence of cyanobacteria
- Identification of species
- Confirmation of cell count equivalent per ml
- Comparison of cell count per equivalent with WHO guidance levels (see Table 3).
- See *iii) Development of environmental monitoring and inspection protocols*
- *See Appendix 3: EA warning thresholds and environmental monitoring procedure*

iii) Development of environmental monitoring and inspection protocols

When there is a proliferation of cyanobacteria (bloom or scum), or the potential for cyanobacteria proliferation, inspection and monitoring should be considered to identify the potential health risks. As stated in the revised EU Directive (2006/7/EC) on Bathing water (Article 8), when the bathing waster profile indicates a potential for cyanobacterial proliferation, appropriate monitoring ahsll be carried out to enable timely identification of health risks [reference].

The need to inspect and monitor a water body will be dependent on the level of risk associated with the site (*see Risk Assessment i) Assessment of water body characteristics and use*) and the nature and intensity of the bloom/scum (*see Risk Assessment ii) Assessment of nature and intensity of bloom*).

Cyanobacteria levels can fluctuate from day to day. Blooms of short duration may be missed by planned inspection and monitoring programmes and routine monitoring may potentially miss maximum levels. While identification of cyanotoxin type and concentration may help support the risk assessment cyanotoxins levels are difficult to quantitatively sample due to their heterogeneous distribution in time and space throughout the lifetime of the bloom.

See Monitoring and inspection protocols below

iv) Incident Management

A multi-agency approach may be required to co-ordinate the response to a cyanobacteria event, particularly when there are potential public health issues (*see Appendix 1: Agencies and stakeholders roles and responsibilities*). See *Table 3: WHO guidance levels on risks associated with cyanobacterial blooms* for guidance levels, potential health risks and typical actions.

Actions may include:

- Restriction of public access to affected waters.
- Prohibition of water contact activities and postage of on-site risk advisory signs (both water body owner's responsibility). It is the owner's responsibility to determine when activities can resume.
- Use of booms: Dependent on species. Booms may not successfully isolate cyanobacteria.
- Communication with public and water body users (see *5. Risk communication* below).
- Consideration of public health follow up
- Water treatment (e.g. barley straw) and prevention of algae growth through environmental management (e.g. reduction of nutrient content, restriction of agricultural runoff and fertilisers; increased water flow and throughput; biomanipulation by zooplankton and macrophytes). Discuss options with EA.

Monitoring and inspection protocols

Environmental Monitoring

Environmental Monitoring is the responsibility of the water body owner.

Public water bodies (local authority)

Sampling procedure

- The EA undertake reactive monitoring of a water body when an incident has been raised either through their incident hotline or local monitoring (No previous abundant population) [2].
- The EA also monitor if bloom/scum formation is suspected following routine sampling.
- The level of monitoring adopted by the EA is relevant to the level of risk (i.e. Risk Category based on nature and intensity of use *see Risk Assessment i) Assessment of water body*:
    - *High risk sites – weekly monitoring until two clear samples have been taken*
    - *Medium risk sites – fortnightly monitoring until two clear samples have been taken*
    - *Low risk sites – monthly sampling until two clear samples have been taken*
- Samples are taken from the leeward shore (worst case scenario).

Sample analysis

- Typical sampling involves:
    - Identification of algal species type to confirm potential toxicity
    - Estimation of cell counts equivalent per ml for comparison with EA warning thresholds defined for toxic cyanobacteria
- While toxicity analysis is rarely undertaken further analysis may be undertaken by the EA to confirm toxicity of a scum or bloom to support decisions regarding potential public health implications of exposure e.g. during large sporting events using the water body [10].

Sample interpretation

- Comparison of cell count equivalent per ml with EA warning thresholds for individual species.

All clear notification

- Once a site is given the "all clear" (based on two clear samples beneath the warning threshold for a given species) [2] the EA will notify the water body owner, with the caveat that the algae could reappear given the correct growth conditions.

See Appendix 3: EA warning thresholds and environmental monitoring procedure for further details

Private water bodies

It is not common practice for the EA to monitor private water bodies. The water body owner may opt to do so privately to support decisions, e.g. when the water body can be re-opened for public use.

Inspection protocol

Inspection is the responsibility of the water body owner.

- Frequency of inspection should be defined by water body use (see *see Risk Assessment i) Assessment of water body*), nature and intensity of bloom. *see Risk Assessment ii) Assessment of nature and intensity of bloom*
- Regular inspection may be required if cyanobacteria is intermittent, scum is present or cyanobacteria cell levels equal 100,000 cells per ml due to the potential for scum formation.

v) Development of local management plans

When dealing with frequently affected water bodies local management plans can be developed detailing strategies for responding to and managing cyanobacteria incidents with potential public health implications. This requires the identification of water bodies prone to algal blooms and the production of generic or individual risk assessments for the identified bodies, detailing predetermined inspection and monitoring protocols and prepared signage and information for provision to the public.

For further details see: "Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health", Scottish Executive Health Department [1].

Traffic light system

For water bodies prone to cyanobacteria incidents a traffic light system, based on the WHO guidance levels can be implemented to support incident management. The availability of suitable infrastructure may restrict the development of such a system. See Table 4 and Appendix 2 for example traffic light system, cyanobacteria levels and appropriate actions.

Table 4: Traffic light system for use responding to cyanobacteria incidents.

Level	Notice	Guidance level	Actions
Red	Scum present in bathing areas	*Cyanobacterial scum formation in bathing areas* *100,000 cyanobacteria cells /ml or 50 ug chlorophyll a/l with dominance of cyanobacteria*	• Possible prohibition of water contact activities • Immediate action to control contact with scum • Consider public health follow up • Hygiene and hand washing advice • Monitoring and inspection
Amber	Algae present	*20,000 cyanobacteria cells /ml or 10 ug chlorophyll a/l with dominance of cyanobacteria*	• Intensify surveillance and protective measures. • Further investigate hazard: Daily/ weekly Inspection for scum formations and conditions conducive to scums • Consider need to restrict/ discourage bathing and other high risk activities. • Non-immersion activities proceed with caution • Post on-site risk advisory signs • Inform relevant authorities • Hygiene and hand washing advice in public toilets.
Green	All clear. No obvious evidence of algae present.	*Less than 20,000 cyanobacteria cells /ml.*	• All clear • No further action required

vi) Risk communication: Information to the public

As stated in the revised EU Directive (2006/7/EC) on Bathing water (Article 8), when a health risk has been identified or presumed, adequate management measures shall be taken immediately to prevent exposure, including information to the public [reference].

Information provided to the public may include [1, 2]:

- Signage, located at access points to affected water bodies. Require updating/removal as appropriate (*see Appendix 6: Example standard warning sign*).

- Public announcements e.g. press releases (*see Appendix 5: Information which may be useful for a press release).*
- Advice to water body users regarding the need to wash if they come in to contact with bloom/scum e.g. Hygiene and hand washing advice/signage in public toilets.
- Leaflets/letters for distribution stakeholders including known water body users (*see Appendix 4: Example letter*)
- Attendance at user group meetings e.g. water sports clubs;
- Production of calendar of events with potential to be affected by cyanobacteria, with alternative locations considered.

References

[1] Scottish Executive Health Department. 2002. Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health:
Available at: http://www.scotland.gov.uk/Resource/Doc/46922/0024256.pdf

[2] Environment Agency. 2009. Managing freshwater and marine algal incidents. Operational instruction 905_08. Issued 14/09/09

[3] World Health Organization. 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management. Available at: http://www.who.int/water_sanitation_health/resourcesquality/toxcyanbegin.pdf

[4] Nichols G., Human health risks from toxic cyanobacteria, dinoflagellates and diatoms, In: Ayres, J., Harrison, R., Nichols, G. and Maynard, R., Environmental Medicine, Hodder Arnold, London, 2010, Section 34, 384-387.

[5] Pilotto, L. S., *et al,* Health effects of recreational exposure to cyanobacteria (blue-green algae) during recreational water related activities *Aust. N. Zealand J. Public Health* 1997(**21***)* 562-566

[6] World Health Organization. 1998. Cyanobacterial toxins: Microcystin-LR in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality. Available at: http://www.who.int/water_sanitation_health/dwq/chemicals/cyanobactoxins.pdf

[7] Environment Agency. 2009. Analysing samples from algal incidents. Operational Instruction 907-08. Issued 14/09/09

[8] National Rivers Authority, 1990. Toxic blue-green algae, Water quality series report No. 2., Bristol.

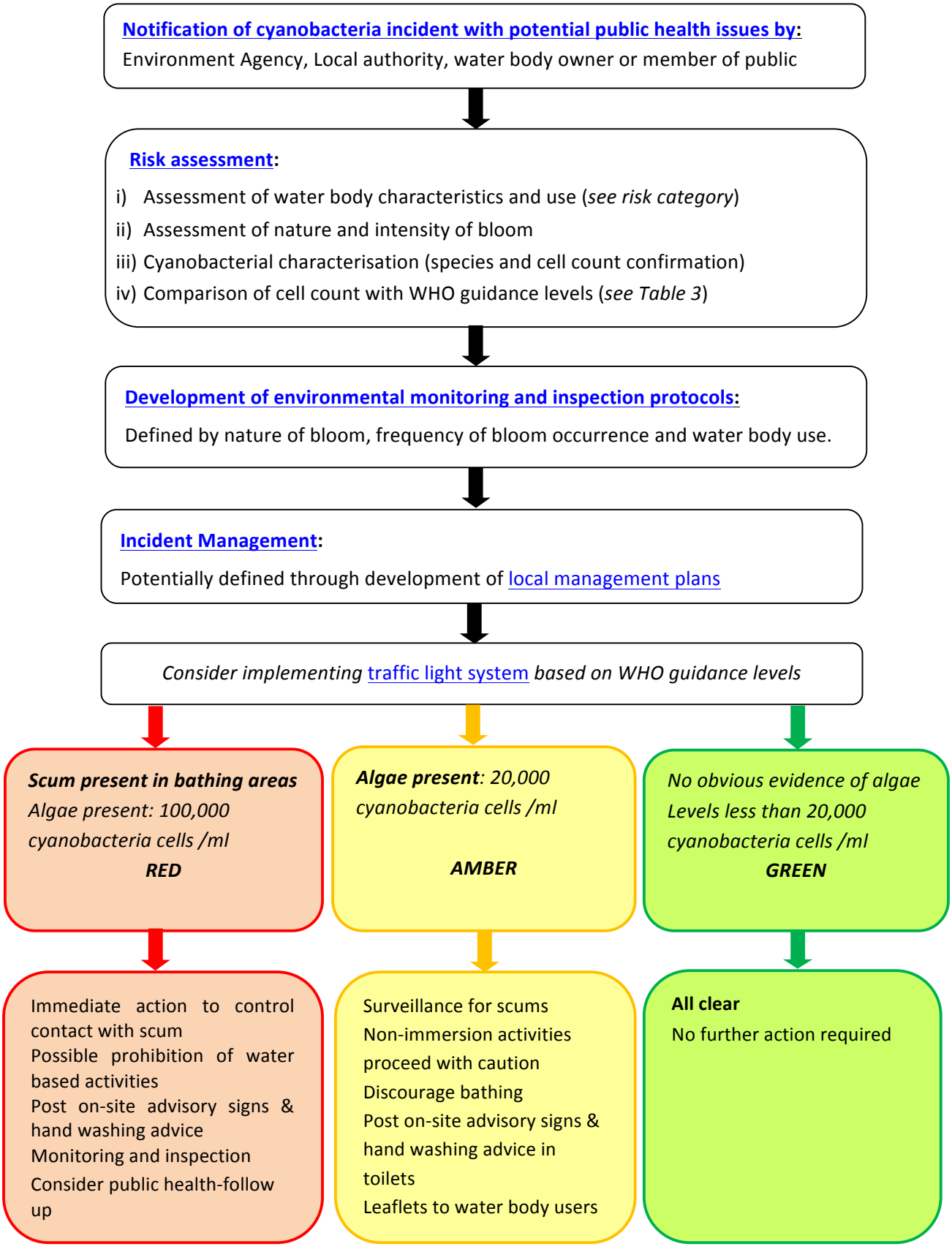
[9] Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC

[10] Environment Agency. 2009. Monitoring Freshwater and Marine Algal Incidents. Operational Instruction 906-08. Issued 14/09/09

Appendix 1: Agencies and stakeholders roles and responsibilities [2]

Agency	Roles and responsibilities
HPA (HPU)	- Notified of incidents with potential public health implications - Coordinate health protection activities - Public health risk assessment through discussion with CRCE - Advice on required actions e.g. the need for closure of water body and warnings to the public, communications strategy etc - Consideration of susceptibility e.g. children (more susceptible to toxic effects and more likely to play in water)
HPA CRCE	- Provide expert chemical and environmental advice on risk assessment and public health risks associated with cyanobacteria. - Advise on public health messages/communications (with HPU) - Advise on key public health actions (with HPU)
National Poisons Information Service	- Treatment of individuals - Consideration of susceptibility
NHS Trust	- Treatment of individuals - Consideration of susceptibility (children / Haemodialysis patients) - Consideration of need for medical follow-up - Clinical sample consideration
Environmental health/pollution department of local authority	- Respond to problems causing statutory nuisance including cyanobacteria blooms/ scums - Coordinate and conduct environmental interventions and risk assessments - Assessment of risks to public health - If LA owns water body see responsibilities below (water body owner) - Provide advice to owners and public about health issues
Water body owner	**The water body may be LA owned or privately owned. The water body owner is responsible for:** - Risk assessment - Undertaking environmental sampling - Warning and informing users of potential risks - Decisions on closure to users (recreational facilities and public access) - Erecting appropriate signage - Discourage or prohibit water contact activities - Decision to reopen
Environment Agency	Responsible for ensuring the quality of water resources (e.g. rivers and reservoirs) - Undertake reactive monitoring in public water bodies with suspected cyanobacteria populations to identify species and cell count. - When cell count levels exceed the warning threshold defined for the species, the EA are responsible for notifying stakeholders (water body owner, local abstractors and the local authority EHOs). - Liaise with lake owners and EHO to assess situation
FSA	Advised by Centre for Environment, Fisheries and Aquaculture Science (CEFAS) regarding occurrence of potentially toxic algae in commercial shellfish harvesting areas - Lead responsibility for issues relating to food safety and animal health. - Involved in incidents with the potential to impact on the food chain
Defra	Defra protects the interests of agriculture, fishing, food and water industries.
Animal health department of local authority	- Advice following animal illness and ingestion. - Identify and inform owners with stock at risk

Appendix 2: Flow chart of actions to be taken in relation to a potential cyanobacteria incident



Appendix 3: EA warning thresholds and environmental monitoring procedure

EA Warning Thresholds & comparison with WHO guidance levels
• The EA warning thresholds provide an indication for the possibility of bloom formation and the potential for scum formation [7]. • The EA warning thresholds are derived from *"information on individual species volume, mass or chlorophyll-a to be equivalent to Microcystis chlorophyll-a concentration of 5 µg/l"* [6], • *EA Operational Instruction 907-08* details warning thresholds for freshwater cyanobacteria found in the UK. • Reporting 'units' vary dependent on species and its colony formation, e.g. gyre is most relevant to circular forming species • **NOTE:** The EA warning thresholds differ from the WHO guidance levels (see *Table 3*). See Table E1 *"Scottish Executive Health Department. 2002. Blue-Green Algae (Cyanobacteria) in Inland Waters: Assessment and Control of Risks to Public Health" [1]* for conversion of EA warning thresholds/reporting units to concentration equivalent to WHO Lower Guidance level *(20, 000 cyanobacterial cells/ml or 10ug chlorophyll a/L)* • See *EA Operational Instruction 907-08* for 'units' at which there is a risk of scum formation.
EA Monitoring Procedure
The EA monitoring procedure is defined by the presence or absence of scum in the sample.
No scum present in sample
1) Confirmation of presence of cyanobacteria. 2) Identification of species to determine potential toxicity. 3) Confirmation of cell count equivalent per/ml. 4) Comparison of cell count against the EA warning threshold defined for toxic cyanobacteria species (see *EA Operational Instruction 907-08*). Reporting units vary dependent on species and its colony formation, e.g. gyre is most relevant to circular forming species. 5) While toxicity tests are rare further analysis may be undertaken to confirm whether a scum or bloom is toxic to support risk management decisions regarding potential public health implications of exposure e.g. during large sport events using the water body [10].
Scum formation
1) If the sample taken from the water body develops a scum the species is identified to determine potential toxicity. 2) The sample is not quantified with respect to cell count. The cell count is assumed to exceed the warning threshold defined in the EA guidance [7]. 3) Visibly clear samples are allowed to stand overnight, under light to enable scum development (if possible). If a scum develops the species is again identified but not quantified with respect to cell count. 4) Further analysis (e.g. cell count in the presence of scum formation) may be undertaken to confirm whether a scum or bloom is toxic in order to support decisions regarding potential public health implications of exposure during large sport events using the water body [10].

Appendix 4: Example letter for public, water body user or stakeholder notifying of cyanobacteria incident

Dear XXXXX

Re: Blue-green algae in xxxxxxx

The Environment Agency has found high levels of naturally-occurring blue-green algae (cyanobacteria) in xxxxx. The type of algae growing in the water is known to sometimes release toxins into water.

Blue-green algae can be toxic to humans following ingestion or skin contact and can cause rashes, nausea, vomiting or diarrhoea. In sensitive individuals some types of algal toxin can occasionally cause liver damage or paralysis although this is rarely seen in the UK. The algae can also sometimes prove fatal to animals. Therefore xxxxx would recommend that no one swims in water near the algae, or touches the scum on the shore. Contact with visible algae, scum and water nearby should be avoided. Children can be more seriously affected than adults due to their greater susceptibility to toxic effects and increased likelihood of playing in the water.

An individual may have had previous exposure to the algae without experiencing any health effects, but this does not mean that they will not experience health effects if exposed in the future, as the levels of toxins in the water are likely to vary.

If the lake is used for recreational activities such as canoeing, swimming, fishing and boating (*add activities as appropriate*). Anyone using lakes and rivers should treat all blue-green algae blooms with caution.

XXX Council is communicating with local businesses about this issue and has erected notices around the lake advising people against drinking the water and to avoid any activities which will put people in contact with the affected water. The levels in the lake are being monitored by *** and you will be advised when the algae clears and normal activities can resume.

While the levels remain high, the following general advice has been issued to:

- Avoid contact with blue-green algal blooms: Do not swim or wade in the water or carry out water sports including xxxxx(*dependent on levels and activities*).
- Children especially must avoid contact with the blooms as they may be more vulnerable to their effects.
- If you have touched the algal material wash your hands immediately. If you come into contact with the algae while swimming or during water sports shower immediately.
- Farmers and pet owners should prevent animals drinking or coming into contact with the affected water. If animals have swum in the affected water they should be hosed down immediately with clean water.
- Medical or veterinary advice should be sought if there are health concerns following ingestion of the water by humans or animals.

If you require further information on blue-green algae and their possible health effects then you should contact xxxxxx (*Add relevant contact details as appropriate)*

Appendix 5: Information which may be useful for a press release

(date)

The Environment Agency has found high levels of naturally-occurring blue-green algae (cyanobacteria) in xxxxx. The type of algae growing here is known to sometimes release toxins into the water.

Blue-green algae may cause illness in humans, following ingestion or skin contact and may cause rashes, nausea, vomiting or diarrhoea. In sensitive individuals some types of algal toxin can occasionally cause liver damage or paralysis, although this is rarely seen in the UK. The toxic algae can sometimes prove fatal to animals. Do not swim in water near the algae, or touch scum on the shore. Contact with visible algae, scum and water nearby should be avoided. Children can be more seriously affected than adults due to their greater susceptibility and increased likelihood of playing in waters.

An individual may have had previous exposure to the algae without experiencing any adverse effects, but this does not mean that they will not experience adverse effects if exposed in the future, as the levels of toxins in the water are likely to vary.

The lake is used for recreational activities such as canoeing, swimming, fishing and boating (*add activities as appropriate*). Anyone using lakes and rivers should treat all blue-green algae blooms with caution. XXX Council is communicating with local businesses and has erected notices around the lake advising people against drinking the water, and avoiding activities which include contact with the water. The levels in the lake are being monitored and you will be advised when the algae clears.

While the levels remain high, the following advice has been issued:

- Avoid contact with blue-green algal blooms: Do not swim or wade in the water or carry out water sports including fishing. Children especially must avoid contact with the blooms as they may be more vulnerable to their effects.
- If you have touched the algal material wash your hands immediately. If you come into contact with the algae while swimming or during water sports shower immediately.
- Farmers and pet owners should prevent animals drinking or coming into contact with the affected water. If animals have swum in the affected water they should be hosed down immediately.
- Medical or veterinary advice should be sought if there are health concerns following ingestion of the water by humans or animals.

The Health Protection Agency have said “Blue-green algae can make people feel quite ill if swallowed or even by just swimming in it. We want people to be careful when using the lakes and rivers for recreational purposes during the summer months. Notices near affected areas should be observed”.

For more information please contact XXX on XXX XXXX XXXX.

Ends

Appendix 6: Example standard warning sign

WARNING

This water contains high levels of blue-green algae which may cause illness in humans and animals including pets

Avoid contact with scum, visible algae and surrounding water

Do not swim in water near visible algae

Do not touch scum on the shore

Wash hands if you touch the algal material

Keep children and pets away from the water's edge

Do not let pets drink the water. Wash pets if they come into contact with water