2.10 Maintenance regime around freshwater wetlands

Kathryn Duchatel[1] **and Anto Pratten**[2]

[1]MWH Gobal, Australia

[2]Stormwater Systems Pty Ltd, Australia

Abstract

Wetlands constructed and occurring naturally within an urban environment suffer from a number of constraints that arise through anthropogenic disturbances within their catchment and surrounding environs. Consequently a wetland in an urban environment cannot be expected to perform as a natural system without regular maintenance.

Regular maintenance requires a suitable frequency of inspections and either the in situ rectification of any issues found, or the scheduling of activities that cannot be achieved during the inspection and/or those activities that require outsourcing or specialised equipment.

Most maintenance activities can be reasonably well forecasted and should be specified in a site specific maintenance plan. It should be similar to management plans and associated monitoring programs for naturally occurring wetlands prepared, which are on a site specific basis.

In order for consistent and regular recording of maintenance and monitoring activities the maintenance plan should include a wetland specific inspection checklist, which identifies all wetland components (mechanical, structural and biological) that should be inspected – and referenced to relevant sections within the plan for guidance.

Consistent and regular recording of maintenance will, over time, provide invaluable information on the wetland's condition and performance. Further this information is critical to guiding longer term management of the wetland including: forecasting of the frequency and type of activities and resources required to maintain or fulfill the wetland's objectives; and enabling early identification and management of issues, which in turn will significantly reduce ongoing maintenance costs.

Introduction

Long regarded as wastelands, wetlands have historically been reclaimed, channelised to convey flood flows; or simply ignored in terms of providing any value to the landscape. It wasn't until the late 20th century that the importance of wetlands and their capacity to filter pollutants from the land became more widely appreciated. Constructing wetlands to combat water-borne and manmade pollutants has become the new 'buzz' in the engineering industry.

In those earlier days, most wetlands were designed with little understanding of the following key factors:

- Ecological processes, which underpin the functioning of a wetland;
- The inability of a wetland to continue to function naturally in an urban environment; and
- The necessity to undertake regular maintenance of an urban wetland in perpetuity.

The advice of wetland practitioners was typically only sought out for the development of a planting schedule, and, more often than not, during the later stages of the wetlands design. By this stage the capital expenditure for the wetland was already locked in, and additional funds for the integration of key maintenance factors rarely available. Maintaining these wetlands to fulfill their engineered design intent soon presented a number of management challenges.

Fortunately, our current knowledge of wetlands has significantly improved. This has resulted in publicly available design guidelines for most Australian climates, provided by relevant state and territory governing bodies.

Both authors of this chapter have been engaged in wetland maintenance during these 'early days'. We trust that our past and present experiences offer useful insight from the many lessons that have been learnt.

What is Maintenance?

Maintenance of wetlands in the urban environment comprises all those activities necessary to achieve goals associated with, but not limited to: efficient hydraulic flow and pollutant removal, aesthetic appeal, public health and safety, and flora and fauna habitat. Most wetland maintenance regimes will encompass two or more of these goals.

Typical maintenance activities involve routine inspections to identify and rectify any issues relating to the following:

- Condition and operational capacity of infrastructure;
- Sediment accumulation;
- Adequate flow;
- Litter and debris build up and blockages;
- Scouring of banks, formation of unintended flow channels within the wetland;
- Subsidence or slumping of both the banks and the wetland bed;
- Condition of wetland vegetation;
- Presence of invasive weeds or pest plants; and
- Presence or indication of pest animals, death or evidence of disease in native fauna.

Monitoring and Maintenance Inspections

A critical component of wetland management and maintenance, monitoring and inspections should aim to generate frequent records from which the wetland's objectives and related performance targets can be adequately gauged.

Monitoring is a term more commonly associated with naturally occurring wetlands and will usually be initiated as a requirement of an existing management plan and subsequent monitoring program. Monitoring programs are typically designed to collect quantitative data (i.e. data that can be analysed statistically) in order to test a theory or hypothesis.

Notwithstanding, a number of commonly recorded data collected during routine inspections of constructed wetlands will provide useful background information, and should also be recorded to supplement quantitative data.

Maintenance inspections typically collect qualitative data (observations), although monitoring programs and the collection of quantitative data may also be undertaken (e.g. water and sediment quality sampling and analysis) as part of maintenance inspections.

Maintenance inspections should be guided by a wetland operational and/or maintenance plan and is likely to involve corrective or regular maintenance activities as well as the collection of data.

Additional Information 1

Tips from lessons learnt:

The use of handheld data collection devices is becoming more widely available and affordable as a resource. They significantly decrease the time and effort required in managing data collected *in situ*. However, always ensure that hardcopies of all data and relevant attributes (i.e. the prompts that data is collected in response to) are taken into the field in case of equipment failure (often as simple as a flat battery).

When using hardcopies always ensure:

- They are checked for readability, scanned and filed electronically on return from the inspection. Ideally the transfer of information collected via hardcopy should be done within one day of the inspection. This will ensure that any illegible scribing is more likely to be recollected from memory of the inspection's outcomes.

And remember you are working in an aquatic environment, hence always use:

- Waterproof pens or lead pencils which won't smudge and risk loss of valuable information; and
- A laser printer or other water resistant printing method for hardcopy reproduction. Most inkjet printing will smear immediately on contact with water and be rendered useless.

Regardless, the effort for monitoring or maintenance inspections will only be useful if all data obtained is:

- Recorded accurately;
- Maintained in a reliable database; and
- Assessed at least annually against objectives and performance targets, and improved upon where necessary.

Maintenance Frequency

Monitoring of naturally occurring wetlands will usually be predefined in accordance with a management plan, monitoring program or potentially as a result of consent conditions. The latter will almost always require that monitoring is designed, approved and detailed in either a management plan or monitoring program.

Routine inspection and maintenance of constructed wetlands will vary in frequency and be dependent on how well the wetland has been designed and installed. As a general guide, monthly inspections are recommended from spring through to, and including, autumn months in sub-tropical, temperate and cooler climates. Inspection frequency may be reduced during winter months, but this must be determined on a site-specific basis.

Inspections will also be required following storm events. A storm event threshold should be determined for the wetland, which when exceeded, triggers the need for inspection. Storm event thresholds will vary for individual wetlands and be dependent on a number of factors including:

- The size of the wetland and its capacity to accommodate and/or convey flows from its catchment;
- Whether the wetland is online (within the main flow path and lacks a high flow bypass) or offline (receives low flows with higher flows diverted through a bypass); and
- The life cycle stage of the wetland, its infrastructure and surrounding environment, for example:
    - older infrastructure may be less resilient to storm flows,
    - newly establishing wetlands will be more at risk of scour, plant loss, or subsidence of finished levels,
    - developing catchments from which sediment loads are likely to vary in comparison to catchments where landuse is relatively static, and/or
    - expected (modelled or predicted) sediment and pollutant loads are yet to be tested (through monitoring). As a consequence, the wetland's capacity to perform as designed is not yet validated.

Additional inspections may also be required due to external queries/concerns (i.e. evidence of fish kills, algal blooms or other issues that have been observed by the public or local authorities).

The most intensive period of maintenance is during the wetland's establishment period (first two years following practical completion of its construction, aquatic planting and landscaping). Weekly or

Additional Information 2

Tips from lessons learnt:

Regular maintenance and preventative actions will significantly decrease the need for more intensive maintenance activities.

Ensuring adequate funds are available for regular maintenance is essential, but not always easily achieved. Those responsible for allocating funds are not always knowledgeable about the risks or implications of letting maintenance activities slide – but they will recognise the economies of scale.

Undertaking a simple cost/benefit analysis will provide a suitable business case to assist in securing adequate maintenance funding. For example:

- The cost of regular weed control and replanting -vs- larger scale weed control programs;
- The cost of stabilising small areas of erosion -vs- repair of failed banks (potentially catastrophic structural failures and resultant damage to infrastructure); and
- Regular removal of accumulating sediment -vs- large scale de-watering and desilting of the wetland and associated disposal costs.

fortnightly inspections may be required during the first three to six months following the wetland's installation, and thereafter reduced as the wetland becomes more established.

Less frequent maintenance activities, such as draining and de-silting of the wetland will be required periodically. The frequency of these activities will depend on how well the wetland is maintained on a routine basis.

Maintenance Plans

All maintenance activities must be specified in a wetland operational and/or maintenance plan, which should be prepared specifically for each wetland. Maintenance personnel and asset managers will use this plan to ensure the wetlands continue to function as designed or continue to fulfil management objectives for naturally occurring wetlands.

The plan must include:

- An overview of the wetland's design intent and/or management objectives, including background information relating to the various functions or values of the wetland that underpin these objectives;
- All maintenance or monitoring tasks and the frequency in which they should be undertaken;
- Maintenance and monitoring techniques, equipment, chemicals, specialist contractors/ consultants or any training of maintenance personnel, permits or licences that may be required;
- Maintenance inspection checklists or monitoring forms;
- Data collection/storage requirements (i.e. checklists, records of maintenance activities, and any monitoring programs and results);
- Consideration of management and maintenance issues, such as:
    - Occupational health and safety (including public safety);
    - Environmental management considerations;
    - Disposal requirements (of material removed); and
    - Access issues;
- Any stakeholder notification requirements; and
- Allocation of maintenance or other management responsibilities.

The plan should also include a labelled schematic layout of the wetland and its surrounds: identifying all structures, plantings, open space, water bodies (see Figure 2.10.1).

High resolution aerial photography is also useful in assessing changes over time in the wetland, such as: sediment buildup; density of macrophtye zones; floating and submerged vegetation in open water zones; and landscaping (see Figure 2.10.2).

Inspection Checklists

Inspection checklists should be developed on a site specific basis so that all components (mechanical, structural and biological) of the wetland system can be checked off as either:

- Satisfactory (i.e. no further action required); or

Figure 2.10.1. Aerial photography used to assess distribution and abundance of macrophytes at Sydney Olympic Park.

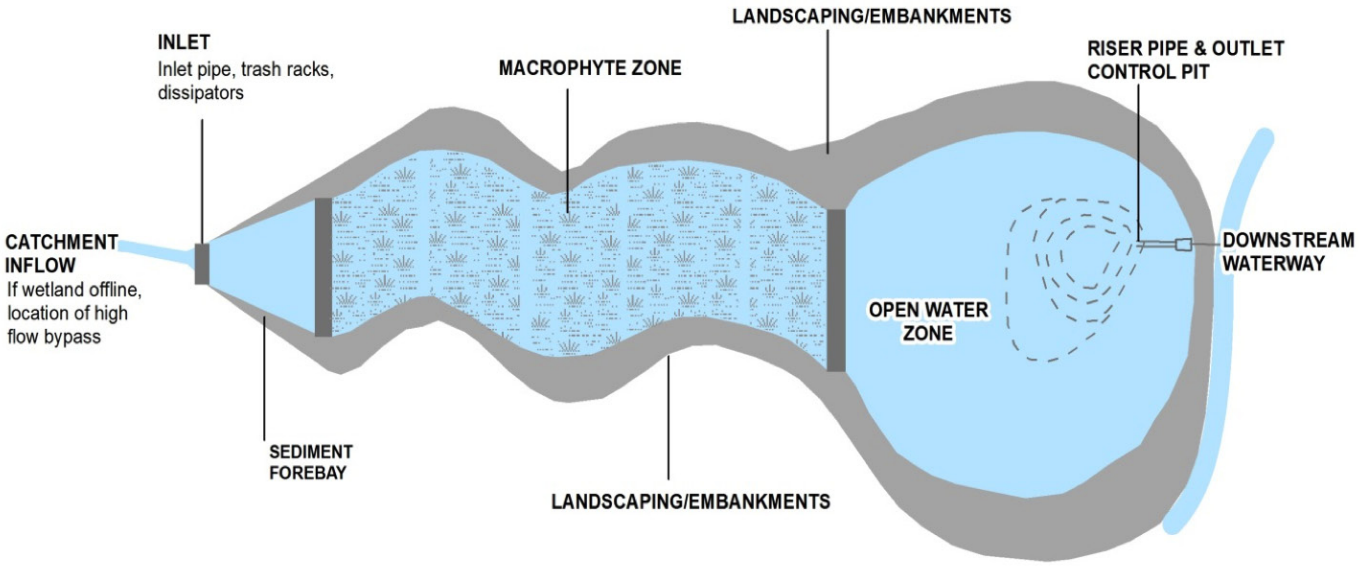


Figure 2.10.2. Simplistic schematic of wetland components*

* The wetland plan does not need to be overly detailed. Conversely, the more simple the diagram, the better the location of identified issues can be marked up during the site inspection. Where there are multiple inflows, inlet and outlet structures, additional plans for specific sections of the wetland, or specific structures in the wetland, may warrant a separate and enlarged schematic for field inspections. From experience, it is very easy to over-complicate a wetland plan. Providing multiple and numbered copies of wetland plans will ensure that all observations and field descriptions can be recorded. A simple notation on the covering plan that refers to additional numbered copies for more detail, will enable ease of later desktop based reporting.

- Scheduled for action (as not satisfactory and in need of either further investigation or corrective action).

Provision should be made within the checklist to record relevant information that will provide an ongoing assessment of conditions within the wetland.

Each component of the wetland requiring either checking off or data recording should be numbered on the checklist such that the inspector is able to cross reference background information and relevant guidance provided within the maintenance or management plan.

Generic fields (that prompt the inspector for input) that should be included in all maintenance checklists include the following:

- Preceding climatic conditions (e.g. rainfall, temperature, occurrence of frosts in cooler climates etc). Recording this information will enable any potential trends to be identified over time, and may provide information on any climatic factors that have resulted in maintenance or other management issues; and
- Entry fields that prompt the inspector to assign whether actions have been undertaken or scheduled, and provide for later sign off on any scheduled activities required. Scheduled activities include all maintenance tasks that cannot be completed during the inspection, and require the following, but may not be limited to:
    - the use of machinery or contractors,
    - consultants (e.g. where specialist advice, or laboratory testing of water or sediments is required), and
    - deferred activities due to rain or winds (e.g. weed control that requires herbicide or other tasks that require water level manipulation, permits/licensing or other notifications).

The maintenance checklist should be used whenever an inspection is conducted and kept as a record from which the condition and performance of the wetland can be measured over time.

The maintenance checklist must remain a live document until such a time when all scheduled tasks have been undertaken and assessed by the inspector or wetland manager and determined to be completed satisfactorily. In finalising a checklist, a record of the effectiveness of activities completed should also be reported and kept on record.

A generic flow chart of maintenance inspection requirements is provided in Figure 2.10.3, and typical checklist items rationale and potential actions required (including whether any maintenance tasks need scheduling) are outlined in Table 2.10.1.

An example of a constructed wetland inspection checklist is provided in Chapter 2.11 Constructed wetlands: design, construction and maintenance considerations.

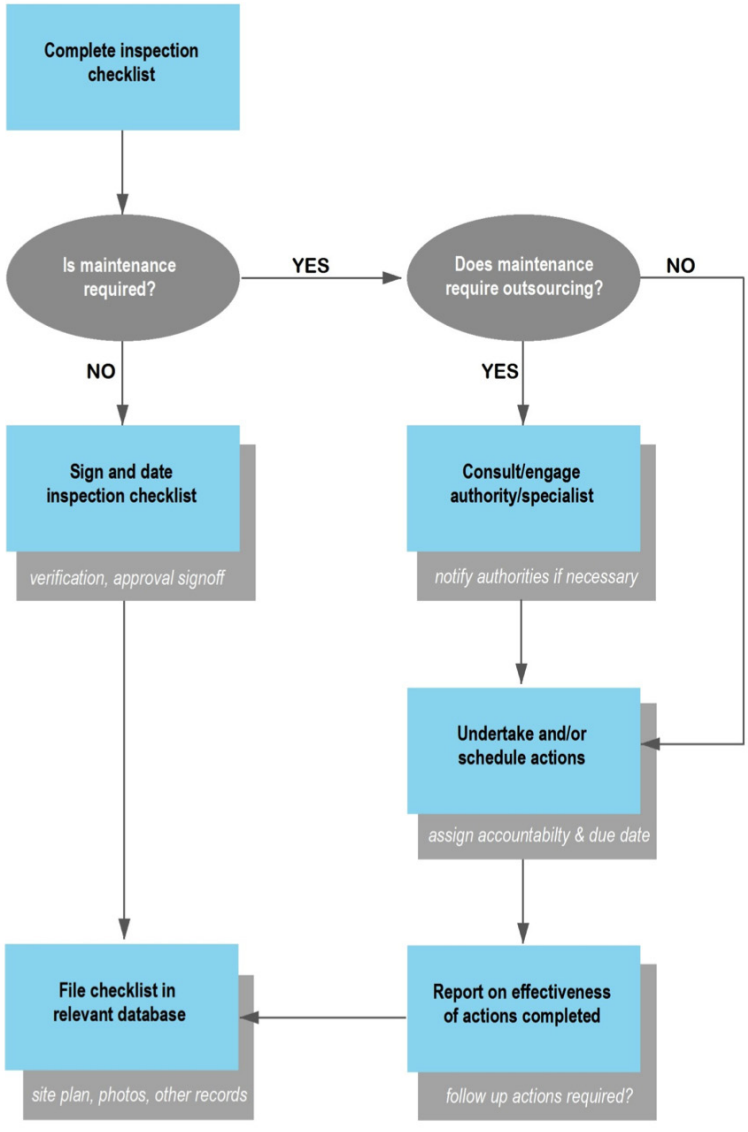


Figure 2.10.3. Maintenance inspection and activity flow chart.

Table 2.10.1. Summary of inspection and structural maintenance requirements.

Component	Inspection	Actions
Mechanical	Mechanical components (e.g. valves, sluice gates, pumps, fence gates, locks and access hatches) should be inspected regularly to ensure they remain functional at all times. All mechanical components should be operated during each maintenance inspection to assure continued performance.	Regularly scheduled maintenance should be performed in accordance with the manufacturers' recommendations, and repairs scheduled immediately where malfunctions are evident.
Structural	Weirs, inlets, energy dissipators, risers, grates, trash racks, outlets, pipes, skimmers, weirs and orifices should be inspected regularly to identify: • Any blockages that may affect flow conveyance; and • Evidence of structural deterioration (e.g. cracking in structures, erosion, leakages or erosion around the structure).	All litter and debris should be removed or scheduled for removal, and engineering inspections scheduled if corrosion or other apparent malfunction are observed.
	Emergency overflow or spillways: inspect to ensure they remain clear of obstacles that may impede flows (including vegetative growth).	Remove any blockages and facilitate any structural repairs immediately to avoid failure during storm events.
	Signage: inspection is required to check signs have not been vandalized and are still legible.	Replace or repair as required.
Embankments, batters, banks	Inspect banks for settlement, erosion, scouring, cracking, sloughing, seepage and rilling, or other instability. Minor erosion should be repaired by replacing soil and stabilising with planting or other methods. Extensive erosion due to continuing discharge may require erosion protection such as rip rap/geotextile.	Record the location and describe the type and extent of erosion observed. Schedule repairs and stabilisation immediately.
Sediment removal and disposal	Regular inspection is required to determine where and how much sediment is accumulating in the wetland. Removal should be scheduled where sediments have accumulated to the extent that the following functions are likely to be compromised: • the storage volume of a stormwater treatment pond, or • the provision of habitat in both constructed or naturally occurring wetlands, or • the capacity of sediment forebays to prevent sediments from entering the wetland. In general the forebay should be dredged if sediment fills over 50% of the design volume. However this threshold should be determined for each wetland.	In many States, sediment and other gross pollutants that have been dewatered are considered putrescible waste. However, this will be dependent on whether these materials contain contaminants. The potential for contaminants in wetland sediments should be evaluated and compared against waste classifications for each State or Territory. Sampling and laboratory analysis may be required.

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

Component	Inspection	Actions
Water body	The wetland's water body should be inspected to determine the presence of any of the following potential issues: • Rubbish and other floating debris; • Sediment accumulation (which may provide a growth medium for weeds or impede flows – see below); • Short circuiting of flows through marsh zones (i.e. the formation of preferential flow paths compared to evenly spread flows through the marsh zone); and • Excessive algal growth, surface scums or slicks. These could indicate water has extremely low levels of oxygen (eutrophication) or high nutrient loads or pollutants.	• Remove rubbish and other floating debris from wetland ponded areas. • Schedule sediment removal as necessary. • Investigate and rectify cause of short circuiting of flows (this may require supplementary planting of macrophytes). • Sample water for algae identification or water quality when these issues are prevalent.
Water levels & other data	Each inspection should record prevailing water levels within the various components of the wetland where standing water is present. This can be measured as depth against gauges or other reliable benchmarks, or alternatively the extent of exposed banks/batters. It is always good practice to record information that may be useful in later desktop based assessments of conditions in the wetland, such as: • Rainfall data – average, minimum and maximum rainfall should be be recorded against the period of time the inspection is reported for. In particular any heavy rainfall events that may reflect changes evident in the wetland or causal factors where malfunctions of structures or erosion is evident. • Temperature data – average, minimum and maximum air temperatures should be recorded against the period of time the inspection is reporting for. In particular, periods of unusually high temperatures or prolonged dry periods, which may be reflected in water levels, changes in macrophyte distribution, abundance or health. • Water flow data – average, minimum and maximum flows should be recorded for the inspection period where stream flow data is available from within the catchment. This data will provide an indication of the quantity of flows that the wetland may have been subject to (dependent on whether the wetland is subject to flows from the sources where stream gauges are present).	Data should be obtained from: • The Australian Bureau of Meteorology or other rainfall or temperature gauges relevant to the locality; and • State government departments for river and stream flow data. This information will be useful in determining whether low or high water levels are a result of climatic events, or potentially whether malfunction in outlet risers, outflow pipes, or leakage in wetland liners of constructed wetlands may be occurring. In naturally occurring wetlands this information would be useful in longer term assessment of water table behaviour.

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

Component	Inspection	Actions
Water levels & other data	**Trouble shooting: water levels remain high or wetland is dry** • Outlet riser openings may be too narrow to allow fast draining after a storm; • Invasive plants clogging pond area; • A maintenance valve is open; • Water leaking from cracks in outlet structure; • Wetland in area of changing groundwater levels; • Ground water level has dropped due to drought conditions, or drought conditions throughout catchment have ceased flows into wetland.	Check all structures for blockages and clear as necessary. Check all drain valves and close if open. Inspect for cracks and leaky joints, and repair as necessary. Further investigations of wetland conditions may be necessary if drought or groundwater levels are not indicated.
Water quality sampling and analysis	Water quality monitoring may be required as a consent or discharge licensing condition, or as a requirement of a current wetland management plan. Water quality monitoring programs will vary in both parameters being measured and frequency. In order to obtain reliable data for annual assessment of a wetland's performance, sampling and analysis of predetermined parameters should be undertaken at least ten times each year (five dry weather and five wet weather sampling events). The number of samples collected and analysed should also be determined for each wetland, but to gain a realistic understanding of water quality over time, the following locations should be tested at a minimum: • Upstream of inflows to wetland (quality of flows into the wetland); • Within the wetland (quality of water in the wetland); and • Downstream of wetland (quality of water leaving the wetland). Replicate samples should be collected from each sampling location to ensure that any anomalies can be identified (e.g. one sample only may inadvertently collect water bird faecal or other matter which may not be representative of average water quality throughout the water body. The design of water quality sampling should also take into account the collection of samples from various depths in deeper zones of water bodies. The number of samples collected will clearly affect the cost of the monitoring program. Hence careful consideration must be given to why water quality is being analysed and how this will guide future management of the wetland.	Undertake, or engage consultants to undertake, water quality monitoring as required. Ensure reporting on sampling and analysis is filed with the relevant inspection records. This should include any exceedance reporting (i.e. specified against each parameter for the locality or against ANZECC or other guidelines). Further information on water quality monitoring is detailed in 4.2 Water Quality monitoring techniques.

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

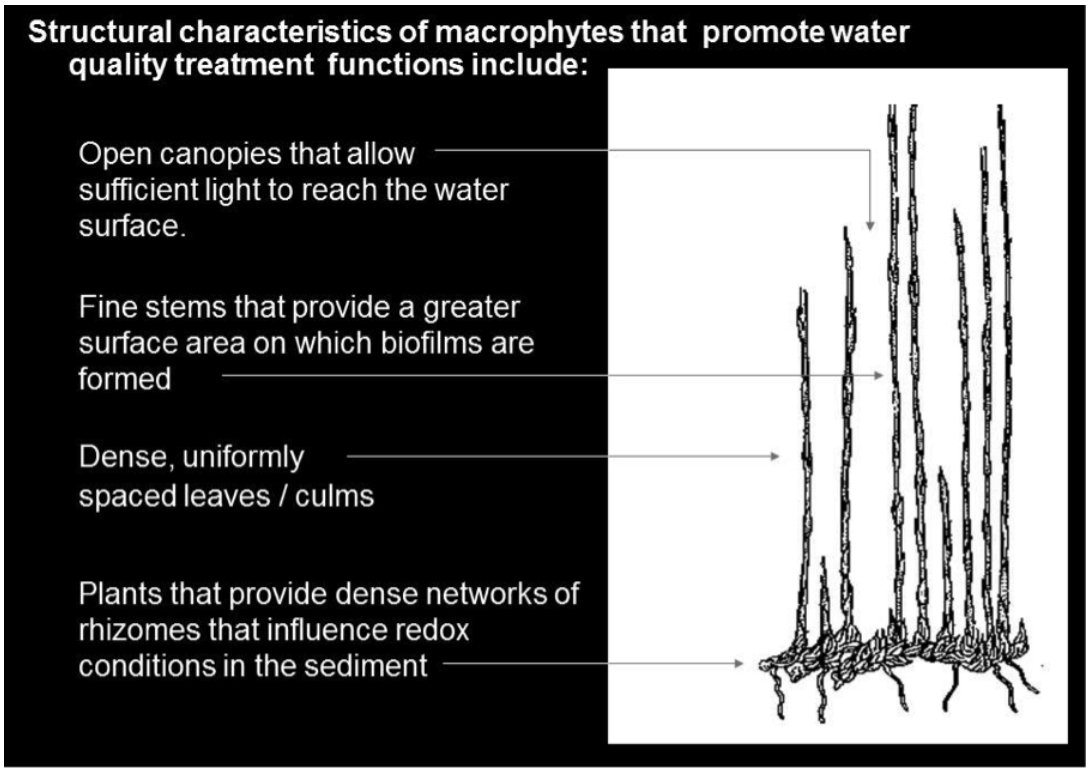
Component	Inspection	Actions
Wetland plants (macrophytes)	Inspection of macrophyte zones (whether naturally occurring or planted) is required to assess the following: • Presence of exotic or invasive/nuisance wetland plant species; • Density and abundance of wetland plants; and • Health of wetland plants.	Schedule: control of exotic or invasive/nuisance plant species; and/or supplementary planting; as required to maintain native diversity and wetland functions in accordance with management objectives.
	Constructed wetlands Attributes of macrophytes specifically suited to wetlands constructed for the purpose of water quality treatment, include those that: spread vegetatively (-vs- those that reproduce from seed only); are perennial (persist year round whether above or subsurface, or both); and have more or less uniformly spaced stems or leaves, which act to levelly spread flows and allow light penetration (in comparison to tufted or clumping species, which promote preferred flow paths and potentially limit light penetration). Structural characteristics of macrophytes that promote water quality treatment functions is schematically presented below:  	
	Naturally occurring wetlands In naturally occurring wetlands, management objectives may be solely focused on the habitat management for a specific threatened species or more holistically aimed at a diversity of species. Statutory obligations often guide habitat management objectives. However, the provision of a diversity of habitats should not conflict with any specific objectives. A diverse and healthy ecosystem will be more resilient to many of the processes that threaten vulnerable species and also provide for a range of habitat functions, including but not limited to: food resources, refuge, roosting and foraging habitat.	

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

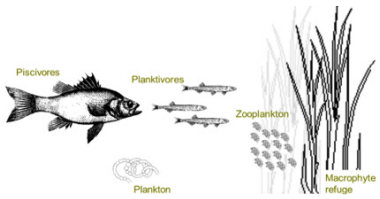
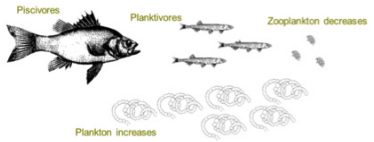
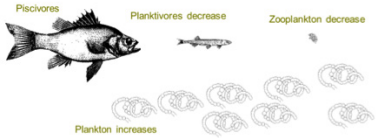
Component	Inspection	Actions
Wetland plants (macrophytes)	These factors should be considered when assessing the distribution and abundance of macrophytes in any wetland, and are equally important in constructed wetlands where treatment of nutrients from catchment inflows is an objective. Macrophtyes provide important refuge habitat for a range of aquatic fauna including but not limited to: • Amphibians (often threatened frog species that are a habitat management objective for many wetlands); • Planktivores: plankton eating fish which are preyed upon by piscivores (carnivorous fish); and • Zooplankton: tiny animals that are usually weak swimmers that feed on phytoplankton. Phytoplankton includes diatoms, dinoflagellates, and cyanobacteria or 'blue-green algae'. Many phytoplankton species when in high concentrations can significantly decrease a wetland's aesthetic amenity and as a consequence cause public concern. Hence sustainable management and/or maintenance of a wetland, whether naturally occurring or constructed, will be underpinned by the provision of a range of habitats that provide for all levels of the aquatic food chain – macrophytes play a key role as illustrated in the below schematics.	
Simplified aquatic food chain	**No macrophyte refuge**	
		
Weeds	Maintenance staff will need to be able to identify major aquatic and semi-aquatic weed species within and around the wetland. When weeds are identified during the inspection, their location should either be marked on a hardcopy schematic layout of the wetland, or GPS measurements taken. Depending on the species and its maturity, immediate manual removal and appropriate disposal off site is recommended. Refer to Chapter 2.5 Control of exotic and invasive freshwater plants and weeds for further information.	Control of weeds unable to be manually removed should be scheduled urgently to prevent the infestation from becoming larger and more difficult and costly to control. The relevant authority should be notified immediately if a Weed of National Significance or other notifiable noxious weed is identified.
Algae	Algae is naturally present in water bodies and algal blooms may occur naturally or in response to levels of nutrients and warm and sunny weather or other imbalances in the wetland (such as stagnation or stratification of deeper water zones). Many species, such as filamentous green algae are relatively harmless. However the presence of blue-green algae warrants vigilance due to its potential toxicity.	Occurrences of dense algal growth should be recorded on the checklist and wetland schematic. Samples should be collected if not able to be identified, and if necessary, specialist advice sought. Refer to Chapter 2.4 Identification and management of freshwater algae for further information.

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

Component	Inspection	Actions
Mosquitoes	Naturally occurring wetlands generally do not produce large numbers of mosquitos due to the presence of predators and other factors which provide a sustainable level of control. However many of the design features that promote water quality treatment in constructed wetlands provide a productive mosquito environment, which in turn poses human health concerns or simply a public nuisance factor. Shallow water (<150mm), dense macrophyte growth, poor water quality and areas of stagnant water in combination will create ideal mosquito breeding habitat. Wetland inspections should include determining whether mosquitos are present or absent from the wetland on a regular basis. This may be limited to checking for larvae or "wrigglers" in pooled water and at margins of the wetland.	The presence of mosquitos should be recorded with a description of the habitat and location in the wetland where they are observed. Where mosquitos became a management concern, specialist advice should be sought. Refer to Chapter 2.6 Managing mosquitoes in constructed freshwater wetlands for further information.
Exotic Fish	Typical exotic species found in urban waterways and wetlands include European carp (*Cyprinus carpio*) and Mosquito fish or plague minnow (*Gambusia* spp.) European carp are introduced bottom feeding fish, which are commonly attributed to turbidity and bank erosion. Many wetland managers undertake periodic electro fishing to control problematic populations of European carp. Mosquito fish are widespread and problematic due to their capacity to prey on tadpoles and other fish. Control is extremely difficult, and usually only achievable where water level control is possible.	Observations of all fish life (exotic and native) should be recorded and where large numbers of such fish are observed specialist advice sought. Refer to Chapter 2.8 Management considerations for freshwater fish for further information.
Avifauna	Public feeding of birds in wetlands can have both detrimental impacts on birdlife and the wetland. Birds readily become reliant on human feeding and will typically concentrate in high numbers around wetlands. This can result in: • Aggressive behaviour; • Malnutrition and/or sickness; • Death of young birds that do not learn foraging skills; and • Rotting bread in the water can lead to additional sickness/disease. Overpopulation of birds in wetlands can lead to: • Botulism and other bird diseases spreading between wetlands; • Decreases in water quality; • Reduction in dissolved oxygen leading to fish kills and other fauna deaths; and • Reduced animal and plant diversity.	Depending on the wetland's management objectives, inspection may require detailed monitoring of bird species and population counts (i.e. where bird habitat is an objective). In constructed wetlands, the type and overall numbers of birds using the wetland and whether damage to plants or other issues observed should be recorded. Public feeding of birds should be discouraged through signage and public education. Refer to Chapter 2.9 Waterbirds: identification, rehabilitation and management for further information.

Table 2.10.1. (cont.) Summary of inspection and structural maintenance requirements.

Component	Inspection	Actions
Avifauna	**Botulism** Botulism is a common killer of wetland birds, which ingest toxins produced by the bacteria *Clostridium botulinum* either from the water or by eating maggots or other infected food sources. Botulism can occur when water levels are low, often mid to late summer when pond water stagnates. It can also appear after algal blooms, when oxygen levels are low. The risk of botulism can be minimized through avoidance of stagnant water (maintenance of flows), avoidance of algal blooms (management of nutrient inputs to wetlands and public education on impacts of bird feeding).	Remove all dead birds from the area to reduce the spread of botulism. Where death of birds becomes more than just an occasional occurrence, dead birds should be tested to determine the cause and specialist advice sought.
Landscaping	Inspection should be undertaken to check for health/vigor of naturally occurring or planted native species and presence of weed growth, and woody vegetation. Growth of woody vegetation can cause root damage to banks and shading of marsh zones, which in turn may diminish growth of macrophytes that require high light levels.	Undertake weed control, replanting and woody vegetation removal as necessary. Removal of woody vegetation may require bank material replacement and repair, compacted to design specifications of maximum 90% soil density.

Concluding considerations

Regular monitoring/inspections and undertaking of maintenance activities are critical in ensuring the design intent or management objectives of a wetland are achieved. Wetland maintenance is not rocket science. Over the past decades substantial research and practical experience has resulted in a wealth of publically available research, case studies and guidelines – all of which should be researched and relevantly considered for wetland maintenance and management on a site specific basis.

Key to successful management will be a sound understanding of the wetland's capacity (or design) to cope with its catchment inputs and immediate surrounding land use impacts and prevailing issues, how each component of the wetland works, and what is needed to ensure the continued functionality of each component and the wetland as a whole.

Regular maintenance and preventative actions will significantly decrease the need for more intensive maintenance activities, which in turn will decrease both effort and funds required over the longer term. This is particularly relevant where resources and funding are scarce. Consistent and accurately detailed maintenance records will provide important management guidance and the basis for securing adequate resources and funding.

Useful Links/Further Reading

Algae

Department of Primary Industries (NSW) Key to Algal Blooms. Available at http://www.water.nsw.gov.au/Water-Management/Water-quality/Algal-information/Key-to-blooms/Key-to-blooms/default.aspx.

Entwisle, T. J., Sonneman, J. A., and Lewis, S. H. (1997). 'Freshwater Algae in Australia. A Guide To Conspicuous Genera.' (Sainty and Associates: Potts Point.)

Waterplants/Weeds

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