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Water Management in Gardens

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Overview

This document is a discussion of water management topics in gardens. It takes a 'beyond the garden fence' approach, placing the garden in the catchment rather than just ending measures at the garden boundary. It argues for a holistic approach that considers water use within the garden as well as beyond the garden and measures that can be adopted to reduce usage as well as maximising rainwater capture while avoiding flooding and building drought resilience. Water management is linked to soil management, planting design, visitor engagement and climate resilience and should be considered within each of these areas, not as a separate entity. It should not be considered as an after-thought and planning is crucial to ensuring a water resilient garden.

Comments and suggestions are welcomed! Please send your comments to: office@plantnetwork.org.

Why the concern for water?

The UK has had one of the wettest winters on record – certainly the wettest February since records began in 1862 – with 209 mm of rain in what is usually the driest month of winter (Met Office, 2020a). This represents an increase of 237% on the average rainfall for February. Winter was also mild with an average temperature of 5.3°C, the fifth mildest on record (Met Office, 2020a). Current climate projections for the UK suggest that this pattern of wetter and warmer winters will become the new normal. April 2020, on the other hand, was one of the driest and sunniest, with a UK average of 29 mm which is 40% of the average April rainfall (Met Office, 2020b). May has been similarly dry. This year alone appears to be conforming to climate predictions for the UK of extreme rainfall events and milder winters as well as the potential for prolonged periods of high temperatures and low rainfall.

Annual average rainfall is increasing in the UK with six of the ten wettest years on record occurring since 1998 (Met Office, 2020a). Winters in 2009-2018 have been 5% wetter than 1981-2010 and 12% wetter than 1961-1990, with summers also showing increasing rainfall (Met Office, 2019). There has also been an increase in average temperature, with 2009-2018 being an average of 0.3 °C warmer than 1981-2010 and 0.9 °C warmer than 1961-1990. All the top ten warmest years since 1884 have occurred since 2002, with the recording of 38.7 °C at Cambridge Botanic Garden on 25th July 2019 becoming the highest summer temperature officially recorded in the UK (Met Office, 2019). Warmer conditions lead to an increase in plant growth rates and with milder winters, an extended growing season. Frost has become less frequent with 2008-2017 having 5% fewer air frost days and 9% fewer ground frost days compared to 1981-2010 (Lowe et al., 2018). Sunnier conditions have also been reported, with 2008-2017 being 3% sunnier than 1981-2010 and 6% sunnier than 1961-1990.

Projections of temperature and rainfall from UK Climate Projections 2018 (UKCP18) indicate in the next 20-80 years that there will be an increase in average temperature and winter rainfall with summer rainfall declining (Lowe et al. 2018). Hence, milder and wetter winters with warmer and drier summers are likely to become the norm, with more extreme rainfall events in winter and increased likelihood of drought in summer.

It isn't just changing weather patterns due to climate change that is altering the balance of the water cycle. There are a number of other considerations that need to be added to the water management mix. The following issues alongside weather and climate are risk factors for water in horticulture: increasing demand for water resources and abstraction from the environment; changes in government policy and legislation; and, increasing development affecting surface run-off and groundwater replenishment.

Water demand

Increasing population growth leads to an increasing demand for water – both at the household level and in the industries and services that support the growing population. There are many measures being implemented to drive down per household/per person average water demand from raising awareness of water use and attempts to alter behaviour (e.g. use of showers over baths, water savers in toilet cisterns etc.) to more water efficient white goods (washing machines, dishwashers, toilets and even taps which reduce flow). Domestic gardens have been estimated to utilise between 5-20% of total household water consumption and 'hose-pipe' bans are a key step implemented to reduce household water demand at times of drought.

Mains water is used in public gardens, alongside groundwater and surface water (river) abstraction licences and often limited rainwater harvesting. Groundwater and surface water abstraction are likely to be the dominant water sources for most gardens but mains water will still be a significant factor, particularly for smaller public gardens and gardens without a borehole/river system nearby. Both abstraction, particularly from surface water bodies, and mains water use in public gardens place pressures on water resource management and the wider environment, particularly as evels of surface water abstraction are considered unsustainable in many water bodies and likely to face restrictions in the future (Water UK, 2015).

Even with current abstraction limits, there is a risk that surface water abstraction for gardens will need to decline to ensure that environmental flows are maintained and as a public water supply resource during times of drought. Groundwater abstraction will be possible provided that aquifers have been recharged during a prolonged period of rainfall (e.g. a wet winter) but extreme drought might also cap this form of abstraction. Groundwater replenishes surface water streams as rivers, as seen with river flow at times of drought, and hence is as important an environmental resource as rivers and streams. Hose-pipe bans, at the household level or temporary use bans (TUBs) as they are now known, remain an option for the water companies to reduce demand of mains water consumption, although through careful planning of their own resources, the aim would be to avoid TUBS. Public gardens also risk being impacted by hose-pipe bans (if non-retail: some exemptions for new plantings, newly laid turf and food crops). Drip or trickle irrigation

now needs an abstraction licence. Stored water (previously abstracted or rainwater) will then be the main recourse to provide a climate resilient solution.

Managing these risks requires knowledge of existing resources that are available. While it might seem unlikely that abstraction and mains water sources will be restricted, it is not impossible given current climate predictions. Investment in water infrastructure such as rainwater harvesting, greywater recycling and flood water storage facilities need to be considered to ensure sufficient water during shortages, while capturing and treating sewage is also a possibility if costly and requiring specialised treatment. Combining storage/water recycling with reducing demand will mean more efficient use of capital investment. Demand reduction starts with limiting wastage by looking at horticultural plans to minimise water use e.g. identifying leaks, reduced watering regimes for established plantings, irrigating turf, etc.

Public gardens rely on visitors – a factor we are very much aware of at this current time. As visitors become more aware of water issues, they will begin to question some of the practices used in public gardens. Implementing water saving measures across the garden, providing interpretation for grey water recycling facilities and rainwater harvesting, and even reducing use of hosepipes will all contribute to building the relationship with water-savvy visitors. We are all becoming more accepting of brown grass during drought – it might not show the garden at its best but there are often bigger issues at play that need to be considered and communicated as amateur gardeners look to public gardens for inspiration and guidance.

Policy and legislation

Despite Brexit, the UK will still continue to implement the Water Framework Directive (WFD) which seeks to improve water quality and water resources for the environment and hence for people. The WFD, together with the Environment Bill in England which is currently being considered by Parliament (suspended in the COVID-19 crisis) and will deliver the 25 Year Environment Plan introduced in 2018 (DEFRA, 2020), will have consequences for water abstraction and mains water use as environmental base flows will need to be maintained at all times, as discussed above.

There will also be increasing measures implemented to help manage extreme rainfall events. Awareness is rising that engineered flood barriers are not necessarily the best solution for flooding, causing problems elsewhere in the catchment, with recognition for catchment scale approaches which will include gardens. There is potential to contribute to 'slow the flow' projects which aim to reduce flooding by reducing the peak flow event: tree planting schemes are one measure alongside the development of porous dams, temporary stormwater storage and installation of sustainable drainage systems (SuDS) (Environment Agency, 2018). Such measures are often supported by government funding.

Urbanisation and development

We are currently experiencing a period of rapid development fuelled largely by a growing population and lack of housing stock. This is resulting in the sealing of the soil, causing greater surface run-off and changes in water demand/resource management (Perry and Nawaz, 2008). While there are incentives and regulations requiring developers to implement sustainable drainage solutions, there will still be an impact on surface run-off in and around

new developments. Much of this is beyond the scope of public gardens but there are potential contributions. Gardens can link with local developments and take some of the run-off for use in water features or direct run-off to storage facilities for later use in the garden. Gardens can also help inform green space on new developments, informing planting and soil management (for improved water holding capacity) as well as creating swales and other water management initiatives so helping to create better links between the new residents and the garden.

There is real engagement potential provided by public gardens becoming involved with new developments to encourage greater participation and interest in horticulture, above and beyond water management, including growing garden visitation, as well as highlighting the role that gardens play in biodiversity, health and wellbeing and persuading homeowners from sealing their gardens with hard landscaping in the future!

What can public gardens do?

Gardens need to be better adapted to changes in rainfall patterns to better manage and recover quickly from high rainfall events. Water resilience needs to be developed, with preparation for extended periods of low or no rainfall while reducing dependence on water abstraction/mains supply. The measures taken might vary across the different regions of Britain and Ireland and will be largely influenced by topography, soils, plant choices and other surrounding land use factors as well as funding availability. There is no 'one size fits all' for water management in a garden. There are a number of different considerations that add to the mix and can help guide the measures that need to be adopted.

Soil

The soil type of your garden does have an impact on infiltration rate, storage capacity and likelihood of surface run-off. Understanding the soil type/s of your garden can help capture as much water as possible and reduce run-off. For instance, a patch of clay soil might make a good rain garden. While there isn't too much that can be done about the existing soil type, there are ways of reducing evaporation, increasing infiltration and reducing surface run-off through soil management. These might include:

- Compaction reduces porosity and water holding capacity and occurs most frequently on clay soil so avoiding compaction on such soils (heavy machinery, footfall etc.) can help reduce surface run-off during heavy rainfall events.
- Use of mulches (if organic matter) and green manures can help improve soil structure and hence porosity whilst also reducing soil erosion during heavy rainfall/wind: a soil protection layer. Mulches also help reduce water evaporation from the soil surface during dry, warm spells as well as supressing weeds which would compete for water/lose water through evapotranspiration.
- Installing permeable paving on paths and other hard surfaces, allowing precipitation to percolate to the subsoil beneath. Examples include resin bound aggregate, permeable block paving and concrete grids.

Topography

Steep sided valley gardens and gardens in flood plains or with nearby rivers/streams will be more prone to flooding. Barriers and gullies can be made to protect the garden and remove excess water as quickly as possible but there might be consequences downstream, resulting in flooding elsewhere. A catchment-based approach is really needed and involvement in

local catchment partnerships will help gardens to understand the wider implications of any measures intended for the garden (e.g. Catchment Based Approach, 2020). Natural flood management (NFM) has been gaining widespread acceptance over the last decade and is a key component of the catchment-based approach which is very much centred on slowing the flow of water to prevent a flood peak from occurring. This includes tree planting (in the right settings) as trees and shrubs can slow the flow of surface water whilst also increasing permeability of the soil, temporary storage measures (in basins, swales, etc.) and even permeable dams.

The natural (or enhanced) topography of the garden can also be used to capture rainwater for diversion to storage tanks to be used during dry periods.

Gardens at high elevations will have higher rainfall than those at lower elevations and hence might be at greater risk of pluvial flood events (flooding caused by precipitation compared to fluvial flooding resulting from high river levels). Hence the location of the garden rather than the topography of the garden itself might be a factor in flood management (see weather/climate below).

Climate and microclimate

Rainfall patterns are not uniform across the UK, with more rainfall alongside the west side of the country compared to the east side: the Lake District (average 3000 mm/year) and mountains in western Scotland (4000 mm/yr) receive considerably more rainfall than eastern England (Bedfordshire, Cambridgeshire, Norfolk, Suffolk, Lincolnshire, the East Riding of Yorkshire and parts of Essex and Hertfordshire) which receive an average of 700 mm/year (Met Office, 2016). While this is an oversimplification, the south and east will be drier and warmer than the north and west. Higher rainfall would also be expected at higher elevations – the Pennine region had some of the highest rainfalls this winter. A number of agencies measure and monitor the water situation in England with reports (usually) publicly available to provide a useful water management planning tool (Environment Agency, 2020).

All regions should consider capturing and storing rainwater – a drought can still occur in an area with high average rainfall and past rainfall patterns are no longer a reliable indicator of future patterns. More extreme events might result in large amounts of precipitation in short periods of time, followed by extended periods of dryness.

Different planting schemes may need to be adopted in different regions: Mediterranean plantings and dry gardens are unlikely to thrive in the wetter parts of the country, although significant soil amelioration will help, but will be perfectly suited to the lower rainfall areas. Temperature will combine with rainfall for different regions contributing to different regional planting choices e.g. alpine plants will be more suited to the cooler and drier parts of the country (e.g. north east) than wetter and warmer regions (south west).

Existing Vegetation and Land Use

The section on soil above considers measures to increase soil porosity and reduce surface run-off/water loss within the garden. The surrounding landscape will also have an impact on the hydrology of the garden as will the built environment within the garden.

Bare soils will have higher run-off than vegetated soils so public gardens surrounded by land devoid of winter vegetation – such as in some arable situations – might be at greater flood risk. There is a similar risk from non-permeable surfaces such as roads and other paved/sealed surfaces. Woodlands have been shown to have a considerable influence on run-off and there are (financial) incentives to plant more trees to 'slow the flow' as well as improve carbon sequestration. However, woodland creation should not be at the expense of other valuable habitats such as heathland and hay meadows. Working with neighbouring landowners or estate managers can make a real difference to water management at the catchment scale, well beyond what a garden might achieve alone, including using water captured elsewhere (e.g. nearby housing development) to water the garden. Also, developments upstream (including flood barriers) might create flooding problems for the garden so involvement at the catchment scale might alleviate future issues which would otherwise incur a cost for the garden.

Sealing surfaces, common in urban environments, will lead to increased surface run-off as water that would usually infiltrate permeable surfaces is directed elsewhere. As was noted earlier, installing porous or permeable materials on paths, allowing precipitation to percolate to the subsoil beneath, will reduce run-off while also capturing water in the garden. If porous landscaping isn't realistic, use of planted swales, ponds or reservoirs/lakes as well as soakaways, trenches and infiltration basins to collect path run-off are alternatives and can be retro-fitted, providing a new planting opportunity (CIRIA, 2016).

Buildings can be used to capture water as part of a rainwater harvesting scheme while a green roof has many other additional benefits (such as additional habitat creation, building insulation/cooling, aesthetic appeal). Rainwater can be directed into rain gardens, swales, soakaways or stored in tanks. Grey/black water can also be reused in the garden (see below). Toilet facilities and cafes/restaurants can be made more water efficient with low volume flush toilets and water efficient dishwashers.

Contaminants and water quality

It is not just water quantity but also the quality of water that is important in water management. Excess watering/rainfall can result in loss of nutrients from the soil, increased levels in groundwater/surface water courses, and hence can be considered polluting (resulting in eutrophication of rivers/lakes). Sedimentation of rivers/lakes is caused by surface run-off and soil erosion, particularly if surfaces are unvegetated, leading to lower water holding capacity of rivers and increased likelihood of fluvial flooding: the sediment might also contaminate the water (fuel, tyre dust, pesticides and nutrients).

Use of grey water is worthy of consideration provided that the wastewater is not too heavily contaminated. Directing water from handwashing and kitchens (if using biodegradable soaps and detergents with limited food waste content) is possible but will have limited application in a large public garden. The recent coronavirus pandemic would indicate that if such water is reused, it is first directed through a series of reedbeds or other treatments, infiltrating the soil towards the end of the process, rather than handled directly by gardeners (Lesté-Lasserre, 2020).

There is always a risk of human or general animal pathogens being present in water abstracted from surface waters (receiving sewage treatment outflows) and shallow aquifers

(through contamination from over-land flow and septic tanks). Viruses, *Escherichia coli* and *Clostridium difficile* can all be present and pose a risk to those in contact. Other pathogens to consider are *Legionella* (which thrives in tepid, stagnant water) and, less commonly, leptospirosis (also called Weil's disease). Exposures to all can be reduced by implementing some standard operating procedures which can include additional treatments (such as UV filtration), preventing water stagnating in pipes/hoses and avoiding the formation of small droplets/aerosols.

Plant pathogens can also be found in water. *Phytophthora* and other plant pathogens can be circulated through irrigation systems.

Smaller steps

Many of the measures discussed above are applicable to the garden as a whole (if not the wider landscape in which the garden sits). There are a number of smaller scale measures that should be considered alongside these bigger issues including, but not restricted to, the following:

- Implement reduced watering regimes – only water new plantings and leave established plantings ('tough love'). As the climate changes, it is likely that there will be losses even with increased watering regimes. This is known as regulated deficit irrigation.
- Plant as much as possible in autumn, winter and early spring to capture the higher rainfall periods and lower rates of evapotranspiration. Watch out for weather forecasts and plant when rainfall is forecast. Water situation reports (England only) might be useful (Environment Agency, 2020).
- Reduce the number of plants in containers as these require more watering, or use self-watering systems with wicking capability.
- Install drip irrigation for container-grown plants in nurseries, hanging baskets etc. as this ensures more efficient water use (waters direct to roots). Water efficiency is further increased if irrigation is timed to early mornings or evenings to reduce evaporation losses.
- Mulch as much as possible (worth repeating!)
- Mow less or strategically – we can all learn to love longer grass which scorches less easily than shorter grass. Grass mazes are great fun for kids of all ages and increased floral biodiversity will be a result, with increased numbers of beneficial insects etc.

Glasshouses and other protected environments

Many of the factors considered below are applicable to the outdoor environment rather than enclosed/protected environments. Nevertheless, all roof areas can be used to collect rainwater and appropriate storage can be put in place to reduce water demand for at least some of the year – even if not used in the glasshouse itself (due to plant hygiene requirements). Appropriate ventilation will also have a significant impact on evapotranspiration loss from protected environments.

Practical solutions

There are a range of potential measures to be adopted by any public garden to improve water management in the garden, leading to potentially reduced costs after initial investment (e.g. reducing storm damage, reduced mains water demand, etc.) and increased environmental performance (e.g. reduced abstraction, reduced downstream flood risk, etc.)

as well as creating new funding opportunities (for catchment-based flood management approaches) and visitor engagement opportunities. The CIRIA SuDS Manual is an excellent resource, containing a raft of practical approaches and solutions (CIRIA, 2016).

Considerations include:

- It is important to develop a holistic approach with large and small measures implemented across the garden. A water management plan will help bring this into focus, identify the areas for drought/flood management, water efficiency measures, and demand management for more effective water use in the garden and link to wider catchment issues.
- Make space for water and allow areas to become temporary water storage areas during high rainfall events. Planting and interpretation opportunities will be created, and it will create an interesting seasonal feature! Other water management features will lead to other planting opportunities, perhaps even introducing new plant accessions to the living collection.
- Speak to neighbours, developers and the catchment manager to link up to catchment initiatives, identify problems before they reach the garden and make best use of resources beyond the garden fence.
- Look at big measures across the garden – including hard landscaping materials, rainwater harvesting – and combine with small scale measures.
- Work with your climate and predicted climate to plant accordingly.

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(Note: all web resources accessed in May 2020).

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