Water by Design (2009) recommends that saturated zone depth should be increased by 120mm for every week of dry weather additional to the five weeks of continuous dry weather mitigated by the recommended minimum 300mm deep saturated zone. The dashed, green line on the graph shows that for 90% of the time on average, a 300mm deep saturated zone will protect a bioretention system in Roma from drying out to the point of leeching (35 days).

The shape of this performance curve enables the informed selection of the 'optimal' treatment size beyond which any further increase in saturated zone depth (and thus cost) yields only limited incremental increase in protection from drought. This so called "point of diminishing performance (or return)" can be considered to represent the reasonable limit of performance of the saturated zone which can then be adopted as the most appropriate depth of the saturated zone.

For example, the dotted, red line on the graph has been plotted to show that if the saturated zone depth was increased by an additional 120mm to provide an extra week of protection this would on average result in the protection of the system for only an additional 1-2% of the time. The cost associated with the construction of an additional 120mm would therefore be beyond the point of diminishing return and an unsustainable option for ULDA and Council from both a life cycle cost and performance perspective.

It is therefore recommended that the saturated zones are not increased in depth beyond the minimum depth of 300mm recommended by Zinger et al (2007a and 2007b).

During droughts[2] which exceed 5 weeks it may be necessary to top up bioretention systems to protect the systems from leeching nitrogen. It should be noted however that carefully selected plant species will be used in the bioretention system capable of survival well beyond the point where the saturated zone dries up and therefore significantly less frequent watering would be required maintain plant viability. Watering and planting is further discussed below.

Watering Bioretention Systems

The need to top up saturated zones will be reliant not only on rainfall but also on a range of interrelated factors including evapotranspiration, plant species and surface runoff as result of base flows (e.g. from lawn/garden watering, leaking pipes etc.). The number of variables makes it therefore unrealistic to reliably predict a top up frequency however there two methods for determining an appropriate watering regime:

1. **Topping up the systems to limit nitrogen leeching and improve denitrification** - topping up to limit nitrogen leaching and improve denitrification should be undertaken after every five weeks where there has been no runoff (including domestic source base flows). As discussed above however, a 300mm deep saturated zone will on average protect a bioretention system in Roma from drying out to the point of leeching for 90% of the time on average.

2. **Topping up the systems to maintain plant health** – topping up to maintain plant health should be undertaken when plants display any sign of stress related to a lack of water. However with water in the saturated zones present for 90% of an average year and species selection based in part on drought tolerance, the systems will remain healthy well beyond five

weeks where there has been no runoff. This means that the likelihood of a dry spell which begins to effect plant health would be very rare.

As with any other public asset in the Maranoa Regional Council the bioretention systems will need to be monitored by the asset manager and managed responsively with more or less watering required depending on prevailing conditions. Watering can be undertaken either via surface irrigation or direct filling via the overflow pits/drainage pipes.

APPENDIX D: ASSET TRANSFER CHECKLIST

BIORETENTION BASIN DESIGN ASSESSMENT CHECKLIST				
Asset I.D.		DA No.		
Basin Location:				
Hydraulics:	Minor Flood (m^3/s):		Major Flood (m^3/s):	
Area:	Catchment Area (ha):		Bioretention Area (ha):	
TREATMENT			**Y**	**N**
Treatment performance verified from curves?				
BIORETENTION MEDIA AND UNDER-DRAINAGE			**Y**	**N**
Design documents bioretention area and extended detention depth as defined by treatment performance requirements.				
Overall flow conveyance system sufficient for design flood event(s)?				
Where required, bypass sufficient for conveyance of design flood event?				
Where required scour protection provided at inflow point to bioretention?				
Bioretention media specification includes details of filter media, drainage layer and transition layer (if required)?				
Design saturated hydraulic conductivity included in specification?				
Transition layer provided where drainage layer consists of gravel (rather than coarse sand)?				
Perforated pipe capacity > infiltration capacity of filter media?				
Selected filter media hydraulic conductivity > 10 x hydraulic conductivity of surrounding soil?				
Liner provided if selected filter media hydraulic conductivity < 10 x hydraulic conductivity of surrounding soil?				
Maximum spacing of collection pipes <1.5m?				
Collection pipes extended to surface to allow inspection and flushing?				
BASIN			**Y**	**N**
Bioretention area and extended detention depth documented to satisfy treatment requirements?				
Overflow pit crest set at top of extended detention?				
Maximum ponding depth will not impact on public safety?				
Maintenance access provided to surface of bioretention system (for larger systems)?				
Protection from coarse sediments provided (where required) with a sediment forebay?				
Protection from gross pollutants provided (where required)?				
LANDSCAPE			**Y**	**N**
Plant species selected can tolerate extended dry periods, periodic inundation and design velocities?				
Bioretention design and plant species selected integrate with surrounding landscape or built environment design?				
COMMENTS				

Source: Water by Design (2006)

APPENDIX E: INDICATIVE MAINTENANCE REQUIREMENTS FOR BIORETENTION SYSTEMS

SCHEDULE OF SITE VISITS													
Purpose of Visit	**Frequency**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Routine inspection	6/year	✓		✓		✓		✓		✓		✓	
Annual inspection	1/year					✓							
Routine Maintenance	4/year	✓			✓			✓			✓		

The above schedule is a guideline only. Inspection and maintenance activities during the plant establishment period (first two years) are likely to be more frequent when frequent weed removal and replanting may be required. Inspections should also be performed after large rainfall events to check for damage or significant pollutant accumulation. Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage. Resetting (i.e. complete reconstruction) of the bioretention basin will be required if the system fails to drain adequately after tilling of the surface. The bioretention basin inspection checklist is based on Water by Design (2006).

INSPECTION	
1	**Routine Inspection**
1.1	Routine inspection should be carried out on a regular bi-monthly basis. The purpose of the inspection is to check for weed invasion, litter accumulation and any damage/vandalism.
1.2	The bioretention system (including floor and batters) should be inspected for weed growth.
1.3	The bioretention system (including inflow points, overflow pits, under-drains and vegetation) should be checked for litter accumulation.
1.4	Identify areas of obvious sediment deposition, damage from vehicles and/ or clogging within the bioretention basin (evident by ponding and/ or 'boggy' filter media surface). If there is shallow ponding or evidence of clogging, firstly ensure that cause is not a build up of sediment. Investigate effect of "turning over" or "tilling" filter media soil, and inspect outflow pipes for clogging.
1.5	Identify areas of erosion, including scouring from storm flows and rill erosion of the batters from lateral inflows.
1.6	Any structures such as maintenance accesses, weirs, piping and access restrictions (eg. lock-rails, fencing) should be inspected for damage and or vandalism.
2.	**Annual Inspection**
2.1	Once per year, the condition of the bioretention basin should be closely inspected. Any damage or problems should be noted on the inspection form for action by the relevant maintenance agency.

ROUTINE MAINTENANCE	
3	**Purpose**
3.1	Routine maintenance of the bioretention system involves weed control and the collection of any litter and minor remedial works if required. If turf has been planted across the surface of the bioretention system, this will obviously require mowing (with mowed grass deposited offsite at an appropriate waste management facility).
4	**Weed Management**
4.1	If weeds have been observed within the bioretention system during routine inspection, these weeds should be removed by hand.
4.2	Where physical removal has been specified, the aim is to remove the weed including the roots when the weeds are less than 3 months old.
4.3	Herbicides should not be used.
4.4	The weeds should be disposed of offsite at an appropriate waste management facility.
4.5	Replant plant species as necessary in areas that have been extensively weeded.
4.6	*In general, the planted species should not be harvested. Harvesting plants has little, if any, benefit for treatment performance.*
5	**Litter Management**
5.1	Remove and dispose of any accumulated litter/debris within the bioretention basin.
6	**Surface Tilling**
6.1	If there is evidence of clogging of the bioretention system, tilling the bioretention basin surface or remove of the surface layer.
7	**Sediment Removal**
7.1	Removal of sediment where it is smothering the bioretention basin vegetation. Remove accumulated sediments by surface scraping (if it does not damage the vegetation too much) or reforming of the bio-retention system.
8	**Under-Drainage Cleaning**
8.1	If the bioretention system is not draining, a reason may be due to the under-drainage being blocked by sediment or litter/ debris. This blockage should be removed by 'rodding' or 'jetting' (using high pressure water) of the under-drainage. As a result, 'rodding' points should be provided at the upstream ends of all under-drainage.
9	**Remedial Works**
9.1	Routine inspection may detect minor damage to the bioretention system after storms that should be repaired. This may include erosion on the bioretention system or scouring at the inlet and/or outlet. This damage should be repaired as part of the routine maintenance of the bioretention system. Measures to reduce future damage (eg. erosion) from occurring should also be investigated and, if possible, implemented.
9.2	Resetting (i.e. complete reconstruction) of the bioretention system will be required if the system fails to drain adequately after tilling of the surface and no evidence of sediment accumulation or under-drainage blockage can be identified.

BIORETENTION SYSTEM MAINTENANCE CHECKLIST			
Asset I.D.			
Inspection Frequency:	1 to 6 monthly	**Date of Visit:**	
Location:			
Description:			
Site Visit by:			

INSPECTION ITEMS	Y	N	ACTION REQUIRED (DETAILS)
Sediment accumulation at inflow points?			
Litter within bioretention system?			
Erosion at inlet or other key structures?			
Traffic damage present?			
Evidence of dumping (building waste)?			
Vegetation condition satisfactory (density, weeds etc)?			
Watering of vegetation required?			
Weed removal required?			
Mowing/slashing required?			
Pruning and/ or removal of dead or diseased vegetation required?			
Replanting required?			
Damage/vandalism to structures present?			
Set down from kerb still present (if road-side bioretention swale)?			
Evidence of ponding?			
Surface clogging visible?			
Drainage system inspected?			
Clogging of drainage points (sediment or debris)?			
Resetting of system required?			

COMMENTS

Source: Water by Design (2006)

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