FINAL

ACT Urban Water Quality Management Infrastructure:

Asset Report

May 2016

Asset 1A: Crace Bioretention Basin - Medhurst Crescent

General information

Description

Bioretention basin in park adjacent to Medhurst Crescent. The system consists of a standard "Minor" GPT upstream of the basin, a coarse sediment forebay at the inlet of the raingarden and a bioretention basin. The basin has a saturated zone. The system is surrounded by a wall.

The bioretention basin was designed and built by the land developer as part of the Crace estate, before being handed over to the ACT Government.

Asset type	Bioretention basin	**Asset context**	Recent greenfield development
Year built	2012	**Year of handover to TAMS**	TBC
Catchment area	38 hectares 'Northern Catchment'	**Catchment type**	Residential and parklands
Filter area	Basin 650 m^2 Inlet 125 m^2	**Total area**	Basin 650 m^2 Inlet 125 m^2
Filter depth	TBC	**Construction cost**	TBC
Total area		**Construction cost**	TBC
Inlet/s	Pipe inlet	**Outlet/s**	Overflow weir
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	

Site inspections

Site inspections have been undertaken on the following dates:

- 15 November 2014 – dry weather/light rain
- 24 November 2014 – wet weather
- 30 November 2014 – wet weather

Design objectives

The bioretention basin has been constructed as part of a treatment train to meet the requirements of the WSUD Code (2009) (primarily the water quality objectives).

It is located in the lower part of the northern catchment in Crace and is the final step in the treatment train before stormwater is discharged from the northern catchment. Downstream is drainage channel which drains around the estate and into Ginninderra Creek on the northern side of Gundaroo Drive.

Performance issues

One of the key performance issues identified at the basin is the failure of the retaining wall around the bioretention system, particularly at the downstream end at the overflow weir. During all site visits there was evidence of water and silt around the base of the wall near the overflow weir and during the second wet weather site visit it was clearly identified that water was flowing underneath the wall (Figure 1).

Water can be seen flowing at base of wall and along path

Water bubbling up at joint between wall and path

Water on path even in a small rain event

Water on path even in a small rain event

Figure 1: Water flowing under the retaining wall (November 2014)

This is most evident when the extended detention is full as the pressure of water increases the flow rate underneath the wall. The flows under the wall significantly compromise the performance of the system as water effectively bypasses the filter media. The flows under the wall also impact on the usability of the path in this location, with water flowing directly over the path and depositing silt on the path. Furthermore the stability of the retaining wall could be undermined over the long term. Water was flowing under the wall in a number of locations.

The bioretention basin is also likely to be suffering from a build up of fine soil particles on the surface of the filter. This was particularly evident during the dry weather site visit where a hard crust was clearly visible on the surface (Figure 2). This crust can form a blinding layer which prevents infiltration through the filter media and causes the majority of water to overflow rather than filter through the media due to the reduced infiltration rates into the filtration media. The impact of this blinding layer was not able to be fully established based on visual observations during the site visits. Often the impact of the blinding layer can be obvious as the bioretention system fails to drain after rainfall however because of the flow under the wall, the blinding layer may be bypassed. The impact of this blinding layer would need to be confirmed with further testing.

Figure 2: Blinding layer formed on filter media surface (November 2014)

Other issues noted at the bioretention basin are:

- The scour pad is difficult to clean and desilt and consideration should be given to the role of the inlet zone and its function and how it is to be cleaned. It is possible that it was poorly designed or that the inlet zone has not been constructed to specification (to be confirmed once the design drawings are reviewed) (Figure 3)

- The GPT is not entirely effective so there is litter accumulating the basin (Figure 4).

- The vegetation is becoming impacted by weeds and the system requires maintenance to reduce the competition to natives in the system

- The bioretention basin has been planted or opportunistically colonised by *Casuarina* trees. Casuarina trees - while suited to the hydrologic regime in bioretention basins – can have an allelopathic impact and can reduce the growth and vigour of other plants (Figure 5)

Figure 3: Inlet zone

Figure 4: Litter accumulating in system

Figure 5: Casuarina trees in bioretention basin

Key causal factors and constraints

It appears that the key causal factor which has led to failure of the bioretention basin wall is a combination of a poor design detail for the retaining wall around the outside of the basin (to be confirmed once the design drawings are received) and/or poor construction of the wall or a combination of both. This physical defect is unlikely to have been influence by deterioration since construction or lack of maintenance.

A key constraint in repairing the flows under the wall is the potential for leakage under the entire length of the wall, and therefore a rebuild of the entire wall is likely to be required. Currently the wall is visibly draining out at the lowest point behind the wall. If, for example, only the northern section of the wall was addressed it is highly likely that water would flow out under the wall at the next lowest point. A summary of the works required to the wall is shown in Figure 6.

Another key constraint in rectification works is that to repair the wall the filter media in the basin would need to be removed for two to three metres adjacent to the wall around the entire edge around the basin. The basin filter media could be carefully stored and replaced.

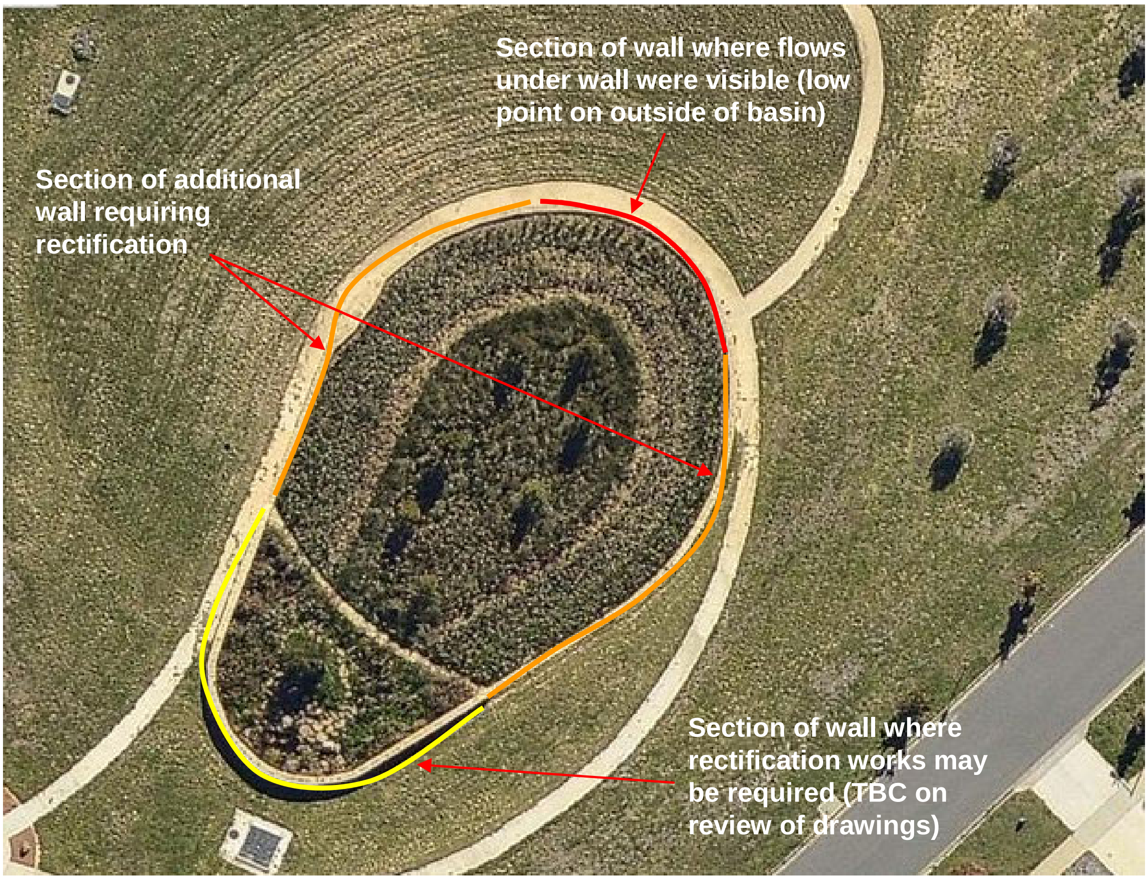

Figure 6: Summary of rectification works required to wall

A key causal factor in the development of the blinding layer to the filter media is the build out of the basin when a large portion of the upstream catchment area was undergoing house construction. This is shown in Figure 7. Discussions with the development manager for the project have indicated that the basin has been affected by construction sediment. The basin was not established offline and stormwater was directed to the basin during the house-building phase.

Figure 7: Portion of the bioretention system's catchment undergoing development at time of build out

Potential improvement options

It is recommended to undertake rectification works to the wall to prevent water flowing under the wall. The exact measures to rectify this issue need to be confirmed once the existing design drawings are reviewed and an informed review of the current defect can be determined. However we expect that external patching of the wall is unlikely to be effective and that rectification will require some sort of lining system to the internal portion of the wall to prevent water flowing under the wall, or some rectification works to the wall itself and its sub-grade to prevent water flowing under the wall. Other options could also be considered once the details of the wall are known.

It is also recommended to:

- Undertake hydraulic conductivity testing on the blinding layer in the basin
- If a blinding layer is confirmed to be reducing the infiltration through the filter media then it is recommended touUndertake a trial of raking the surface to break up the blinding layer, without doing significant or terminal damage to the vegetation, and then reassess the hydraulic conductivity of the filter media. It is noted that the follow up testing needs to be carefully considered and conducted to be successful
- If the above is found to be unsuccessful, then approximately the top 100 mm layer of soil will need to be removed (exact depth to be determined based on site investigations above) and ideally replaced or at least permanently removed. The vegetation will need to be removed and replaced. Ground cover plants may be able to be salvaged and re-planted through careful construction methods.

It appears that the basin is significantly undersized. Review of the DA information may help to clarify the design intent and to better understand the strategy for the basin. If the basin is confirmed to be undersized it is likely that high sediment loads will continue to compromise the basin's performance and that either a more frequent maintenance regime would be required, or the flows diverted into the system should be reduced to ensure it can function appropriately.

The basin would also substantially benefit from the following minor maintenance works

- Weeding of the entire basin
- Removal of litter from the basin
- Removal and/ or replacement of the casuarina trees

Consideration needs to be given to how the coarse sediment forebay is to be maintained, including further discussions with maintenance staff about the current arrangement and their ability to clean the current forebay and potential future arrangements and configurations. Partial removal of the wall may need to be considered to allow for access, although visually it would be preferable if this could be avoided.

Asset 1b: Crace pond and wetland

General information

Description

In the main recreational park within Crace there is a pond and corresponding recirculating wetland. Water from the majority of the development, including most of the southern part of Crace, discharges to the pond before overflowing to Ginninderra Creek.

The pond has two main inlets and a number of smaller inlets into the pond. The pond and wetland are surrounded by soft landscaped edges and a combination of crushed granite and concrete pedestrian paths.

Asset type	Pond and Wetland	**Asset context**	Recent greenfield development
Year built	2012	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Predominantly residential with some retail
Normal water level (NWL)	Pond: TBC Wetland TBC	**Top of extended detention**	Pond: TBC Wetland: TBC
Surface area at NWL	Pond: 5,100 m^2 Wetland: 4,400 m^2	**Open water approx. %**	Pond: 100% Wetland: 10% (design) Wetland: 60% (actual 2014)
Volume at NWL	TBC	**Volume at top of extended detention**	TBC
Average depth at NWL	TBC	**Maximum depth at NWL**	TBC
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	2 main pipes discharge into the pond with a number of smaller inlets	**Outlet/s:**	10m long Overflow weir into culvert and into Ginninderra Creek
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings		✓	✓

Site inspections

Site inspections have been undertaken on the following dates:

- 16 October 2014 – dry weather
- 15 November 2014 – wet weather
- 30 November 2014 – wet weather

Design objectives

The Crace pond and wetland have been constructed as part of a treatment train to meet the requirements of the WSUD Code (2009). The Crace wetland and pond also has the purpose of:

- Treating a small portion of Crace in the wetland by diverting stormwater flows into the wetland
- Keeping the water body healthy by recirculating the flows from the open water pond through the wetland
- Providing a key landscape element in the main recreational park within Crace, the wetland and pond include paths, educational, signage, viewing platforms, and formal and informal landscaped edges.
- Habitat value (however it is not clear whether this was a key objective which influenced the design).

The wetland and pond are located at the downstream end of the catchment and are the final step in the treatment train for stormwater management at Crace. Downstream of the pond, stormwater is discharged from the pond into Ginninderra Creek downstream of Gungahlin Pond. Giralang Pond and Lake Ginninderra are downstream.

Performance issues

The Crace pond and wetland operates in two different modes:

- During dry weather, it functions as a recirculating system, with water being pumped from the pond through the wetland at a slow flow rate through the wetland to maintain the quality of the water in the pond
- During wet weather, most of the stormwater flows into the pond at high flow rates and the water level in the pond rises. The dominant flowpath is directly through the pond from the inlet to the outlet of the pond. The wetland is effectively offline during stormflows with water not passing through the wetland cells. However a small portion of the stormwater flow is diverted into the wetland (a 450mm pipe is diverted into the wetland from the 'Abena Ave catchment')

In the dry weather recirculation scenario, the wetland, while generally stable, has the following key issues which mean that the wetland is not functioning as intended:

- The flow path through the wetland is seriously compromised. The intended flow path is for water to be directed through the entire vegetated component of the wetland. This is shown in Figure 1 via the blue dashed line flow path. However the central embankment does not extend all the way to the eastern edge and hence flows actually completely bypass the wetland vegetation (as shown by the actual flow path by the red line in Figure 1).

- To be effective, the wetland cell needs to be entirely planted across the wetland. As can be seen in Figure 1 and Figure 2 there are large areas of the wetland which are un-vegetated. The red line in Figure 2 shows how the flows are bypassing the wetland vegetation and significantly reducing the treatment that the recirculation flows are achieving in the wetland. A review of aerial imagery in Nearmap shows that this area of vegetation has not been successfully established at any time. This suggests that rather than the planting being established properly and then dying back the wetland plants have never been properly established. It is likely that either the vegetation failed almost immediately after planting or the wetland cell was not actually entirely planted as per the planting plan - as the planting plans for the wetland shows that these areas were intended to be fully vegetated.

Based on site observations the recirculated flows are relatively low and with low velocities as would be expected. The wetland does not have any extended detention, with water flowing out through a relatively large culvert outlet into the pond. This culvert outlet does not restrict these low flows in the wetland.

In the wet weather scenario, the wetland appears to be generally stable hydraulically with the following observations:

- The wetland is not functioning as a true stormwater treatment wetland due to the lack of extended detention and hence the wetland is ineffective at treating stormflows into the wetland. This is a critical failure in the design of the system.

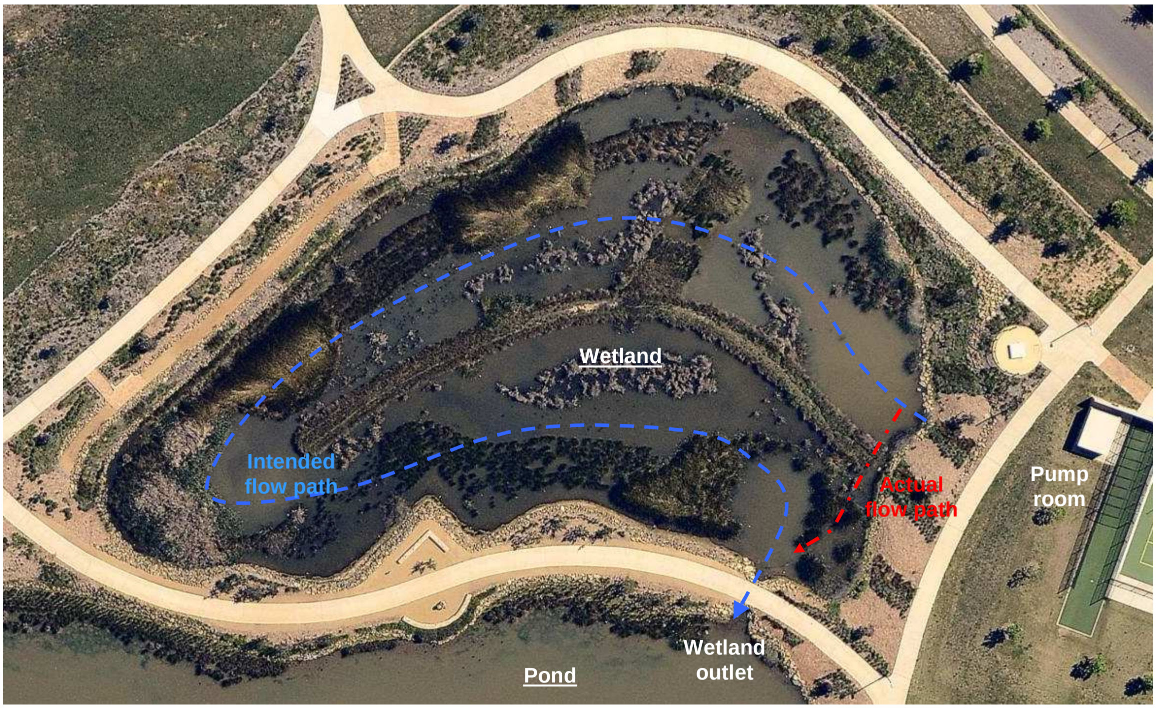

Figure 1: Recirculation flow path: intended vs actual flow path

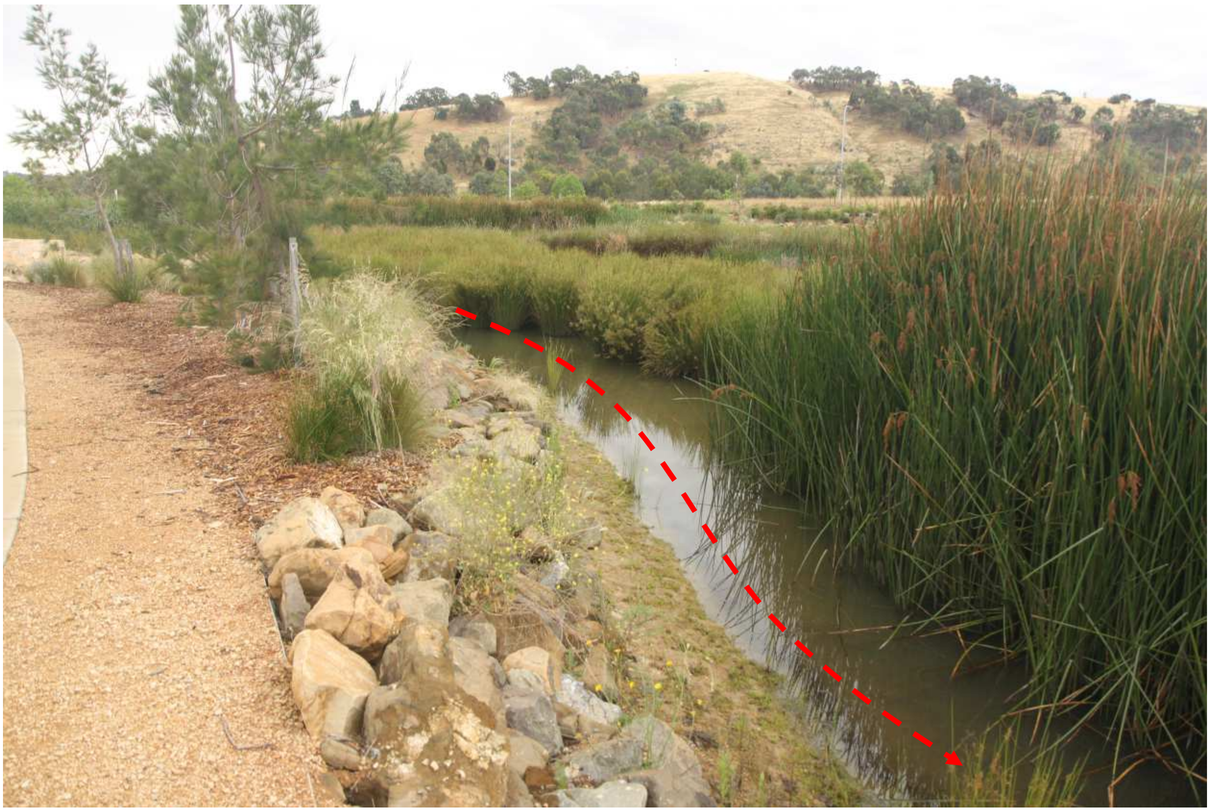

Figure 2: Lack of full wetland vegetation coverage allowing bypassing of the vegetation (red dashed lines indicates dominant flow path bypassing vegetation)

September 2012

March 2013

Figure 3: Lack of full wetland vegetation coverage over time (images sourced from Nearmap)

In the wet weather scenario, the pond appears to be generally stable hydraulically with the following observations:

- The main inlets are partially submerged and hence the flows into the pond are dampened by the tailwater level in the pond and no signs of erosion, scour or similar were present
- Storm flows are effectively short-circuiting through the pond due to the arrangement of the main inlets in relation to the pond outlet. The flows are following the shortest possible path through the system, through the centre of the pond in open water and out of the system. This leaves a 'dead zone' within the pond which is poorly flushed due to the lack of flows through this part of the system. This is shown in Figure 4. This is somewhat alleviated by the action of recirculation which alleviates the dead zone as the water enters this part of the pond from the recirculation wetland
- The outlet was observed during wet weather events to be operating effectively and was hydraulically stable with no signs of erosion, scour or similar, as shown in Figure 5

- The pond has no extended detention, so there is only a short residence time for stormwater flows and limited contact time in the pond zone with flows passing through in a matter of minutes from inlet to outlet

- The pond banks are relatively steep, with slopes of 1 in 3 or steeper observed on site. Furthermore the edges include rock along the edges which makes egress out of the pond more difficult. Good vegetation establishment is important to exclude people going down to the edges and reducing the potential hazards of drowning.

- There is generally good establishment of vegetation around the edges of the pond although in some locations it is patchy. Edge vegetation is important for excluding access to hazardous areas.

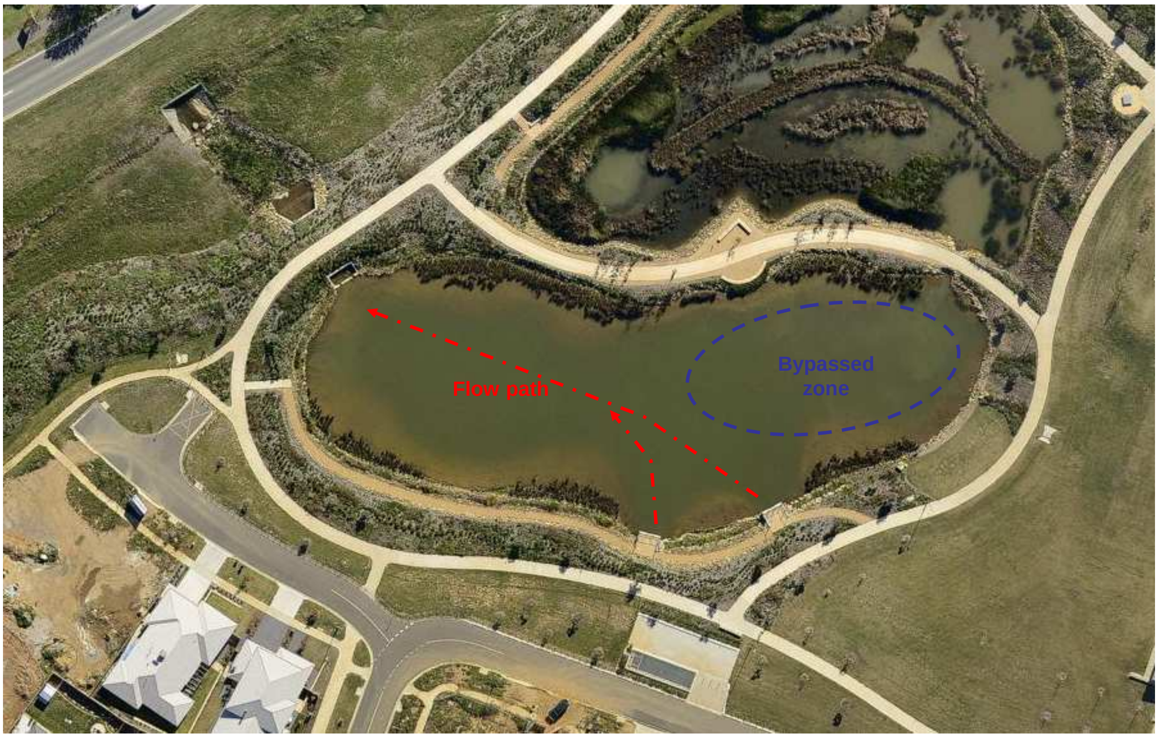

Figure 4: Pond outlet operating during wet weather event

On site we also observed some other minor performance and landscaping issues:

- Litter accumulating around the pond edges, suggesting that the gross pollutant treatment is not effective at capturing floating litter, such as plastic bottles, cans, etc

- Weeds growing in the crushed granite path along the south western edge

- Patchy vegetation establishment on the dry banks and ingress of weeds on the south western edge of the pond

These issues are shown in Figure 6.

Figure 5: Pond outlet operating during wet weather event

Figure 6: Minor issues at Crace pond and wetland. Left – floating litter washed onto banks. Right weeds growing in crushed granite path and adjacent to path

Key causal factors and constraints

The key factors which have led to the significantly compromised performance of the Crace recirculation wetland is the bypassing caused by the incomplete embankment and the lack of good vegetation establishment.

The cause of the bypass in the embankment detail is:

- A lack of detail in the design drawings
- Specifically the Civil Engineer’s grading plan is unclear (there are no details of grading in the landscape package). The wetland berm is shown below the water level in the grading plan but this is not what has been constructed on site

- A lack of sections through the wetland provide little detail on how the central berm is intended to be constructed

- In general it appears that neither the landscape drawings nor the civil engineering drawings have adequately documented the wetland

The lack of extended detention in the wetland is a design failure. The wetland outlet is detailed with only a culvert outlet and has no extended detention included in the wetland designs. This key omission significantly restricts the potential of this wetland to perform as an effective stormwater treatment system.

The cause of the lack of vegetation establishment could be caused by a number of factors including

- Inappropriate selection of vegetation

- Planting may not have been adequately completed or may have been planted with small stock which was drowned shortly after planting

- Poor vegetation establishment practices after planting

- Poor wetland soil material (there does not appear to be any specification of the soil type for the wetland)

The planting plans also have used a strategy of planting in large single-species stands (e.g. one species per planting area). This planting strategy is high risk because if the species is unable to withstand the water level regime in that location, the failure will mean a whole area of the wetland is left unplanted. This has happened at Crace. It is strongly recommended to plant wetlands out with a diverse range of species as many wetland species grow in specific water depths and water regimes and a planting of a single species can frequently fail in wetlands. If there is diversity of species this assists in ensuring that even if one species fails there is reduced risk of lack of vegetation establishment in one whole zone of the wetland.

The poor vegetation establishment should also be picked up by the ACT Government in an asset handover inspection. Poor vegetation establishment is easy to assess both in the field and using aerial photography such as Nearmap. This is a common issue for vegetated wetlands where wetland vegetation establishment is not only more difficult than terrestrial vegetation, but also prone to poor establishment practices by construction contractors.

The main issues with the existing pond are caused by the design of the pond. The lack of extended detention has not been included in the design drawings and the poor mixing is caused by the inlet arrangement.

A further design flaw in the pond and wetland is lack of water level control. Without water level control it is difficult to modify the water level to help establish vegetation, desilt the system, or undertake general maintenance

Other minor issues, including litter and weeding are a combination of a poorly performing GPT and lack of recent maintenance of the pond.

Potential improvement options

The following options are recommended for further consideration and analysis to improve the treatment performance of the wetland:

1. Rectify the embankment works in the wetland to prevent the short circuiting of the system

2. Re-establish vegetation in the wetland throughout the entire macrophyte cell (further investigations into the failure mechanism of the vegetation is recommended prior to this being undertaken)

3. Modify water levels in the wetland system to incorporate extended detention and increase the notional detention time (include a riser outlet)

4. Include water level control in the wetland to allow for maintenance particularly wetland vegetation establishment and desilting the sediment basin and general maintenance procedures

5. Review the recirculation pump rate to ensure it remains appropriate

With regards to the pond:

- The short circuiting of the pond is difficult to rectify at this stage without earthworks in the pond itself

- Extended detention may be able to retrofitted to improve performance:

    - One potential option is to include extended detention by lowering of the pond water level and retrofitting the extended detention to the top of the existing normal water level. This would have an impact on the aesthetics of the pond, and additional planting would be required. The benefits would need to be considered.

    - Including extended detention above the normal water level would have to consider any impact on potential increase in flood levels in the upstream stormwater system

- Re-establishment of vegetation on both the dry and wet edges to ensure that edges are well planted and particularly from a safety perspective are preventing access to the

- Consideration should be given to retrofitting water level control into the pond to allow for desilting and maintenance

- The performance of the GPT should also be reviewed to see if it can be improved to prevent litter entering the pond.

Asset 2: Abena Ave rain gardens (Crace)

General information

Description

There are 16 rain gardens on Abena Ave in Crace between Chance St and Galore St. They are all built to the same design, and are located in the verge on either side of each intersection.

Each raingarden has two cells, except for two of the raingardens. There are typically two inlets from the kerb at each end of the raingarden, one into each cell. The cells are divided by a small concrete weir.

The raingardens include street trees and understorey planting. The raingardens are located in a street which has a mixture of dwellings including apartments and terraces.

Asset type	Rain gardens (streetscape)	**Asset context**	Recent greenfield development
Year built	2009-10 (8 western systems) 2011 (8 eastern systems)	**Year of handover to TAMS**	TBC
Catchment area	9,600 m^2 of road catchment	**Catchment type**	Road runoff
Filter area	12x Approx. 75 m^2 2x Approx. 40 m^2 2x Approx. 30 m^2	**Total area**	1040 m^2
Filter depth	TBC	**Construction cost**	TBC
Inlet/s	Open edge on street side	**Outlet/s**	TBC
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	

Site inspections

Site inspections have been undertaken on the following dates:

- 16 October 2014 – dry weather
- 15 November 2014 – wet weather
- 30 November 2014 – wet weather

Design objectives

The Abena Ave rain gardens have been constructed as part of a treatment train to meet the requirements of the WSUD Code (2009).

The rain gardens are located in the middle of the catchment and are the first step in the treatment train. The rain gardens are part of the treatment which drains to the pond and recirculating wetland in the main Crace park. Downstream of the pond, stormwater is discharged from the pond into Ginninderra Creek downstream of Gungahlin Pond. Giralang Pond and Lake Ginninderra are downstream.

The raingardens have been designed and constructed to treat the overwhelming majority of the streetscape of Abena Ave. The systems generally do not appear to have connections to the footpath or to the lots, although there are a few direct connections from the lot into the back of the raingarden. It is currently unclear whether the rain gardens were intended to treat the runoff from private lots or only from the streetscape as the systems are significantly oversized if they are designed to treat only the road catchment.

12 of the 16 raingarden inlets are well located upstream of the stormwater drainage, ensuring that runoff has a chance to enter the inlets prior to entering a pit, however 4 of the systems have no effective catchment draining to the system, typically with a pit immediately upstream of the raingarden inlet which prevents any water from entering the raingarden.

Performance issues

At Abena Ave, construction activity including house-building has been entirely completed and the systems are no longer affected by construction sediment. The western half of the systems generally have well established vegetation (these systems were constructed earlier than the eastern half) as shown in Figure 1. The eastern half of the rain gardens are currently still in the establishment phase, with vegetation coverage increasing but still not providing significant coverage of the filter media as shown in Figure 1.

It appears based on analysis of recent historical aerial images using Nearmap that during construction the eastern end systems were built out prior to the construction of the houses and then protected with a plastic liner.

Our observations of the raingardens on Abena Ave were that:

- Approximately 25% of the raingardens have no catchment, typically because this is a pit immediately upstream of the raingarden inlet (refer Figure 2)
- Approximately half of the kerb inlets are blocked at Abena Ave and are not functioning. Runoff is completely bypassing the inlets and is draining to the standard stormwater pits
- One raingarden had a structural defect with the concrete at the inlet tilting the *away* from the raingarden directing the water around the raingarden
- In most cases a slight build up of debris including sediment and organics caused blockage (refer Figure 3). However in many cases, partial removal of the sediment and debris and some of the mulch manually (to simulate maintenance activity) had little effect on encouraging water to enter the system

- The systems were also depositing substantial sediment in the gutters throughout Abena Ave, potentially the result of minor works in the catchment

- Approximately 25% of the systems had inlets that were functioning. Some of these systems were partially blocked but were still functioning well. The systems that were functioning had a clear grade at the inlet towards the raingarden reducing and in some cases effectively eliminating sediment build up at the inlet. Figure 4 shows a functioning inlet, and the increased grade on the kerb into the raingarden is clearly visible.

- Some of the trees have suffered significant damage and in a few systems the trees have failed to establish at all and are no longer present (refer Figure 5)

- In a few cases significant vegetation establishment right at the inlet is preventing water from entering the raingarden

- Where present and visible, inlets from the lot are working well, with a slight area of scouring at the inlet although this is not considered a significant issue

- In approximately 4 of the 16 systems water was successfully entering the inlets and the inlet was able to capture the entire low flows in the gutter. Water was witnessed ponding over the surface (refer Figure 6). It appears that based on the extent of extended detention the areas at the edges of the rain garden are unlikely to engage before water starts to overflow from the system.

- There was evidence of litter and weeds in the rain garden, but not substantial amounts and would not take a significant effort to remove (a few minutes for each rain garden, no more than 10 minutes for the whole street)

- The subsoil drains have been installed as flexible polypipe and it appears that the sock has been left on the polypipe. This is generally not recommended due to the potential for the fabric to clog over time.

The rain garden cells that had functioning inlets had clear signs of deposition of sediment and debris on the rock mulch. Those systems which had blocked inlets had very clean rock mulch suggesting that flows have rarely entered these rain gardens and that only relatively small amounts of debris were required to block the inlet.

Based on site observations to date the filter media appears to be draining well. Water is only ponding on the surface for short periods after rainfall. Hence it appears that the filter and subsoil drainage are all adequate.

Figure 1: Rain garden on Abena Ave, showing vegetation establishment. Left hand photo showing typical western Abena Ave rain garden and right hand photo showing typical eastern Abena Ave rain garden.

Figure 2: Example of a rain garden with a stormwater pit immediately upstream of the raingarden inlet

Figure 3: Example of a rain garden on Abena Avenue, with blocked inlet caused by sediment

Figure 4: Example of a kerb inlet functioning well and delivering water into the rain garden. Water is flowing right to left and note the lack of water on left hand side of kerb and water ponding in the raingarden (as evidenced by darker sediment)

Figure 5: Rain garden on Abena Ave, with significant tree damage

Figure 6: Extended detention is engaged during rain event where inlet is functioning

Key causal factors and constraints

Issues around the location of the stormwater drainage pits immediately upstream of rain gardens are fundamental design issues which should have been resolved at the estate development stage. These basic physical features of the drainage system are difficult to change now.

Generally as the raingardens have not been constructed with a sufficient drop from the inlet to the filter surface, flows are generally prevented from entering the rain garden and hence are unable to pond on the surface. The systems appear to have limited extended detention. The lack of a drop and the lack of extended detention between the kerb inlet and the filter surface level is the major factor driving the failure of the system.

A secondary factor is that the inlets are relatively small. The size of the inlets makes them vulnerable to blockage. For example one plastic bag or A4 sheet sized piece of cardboard can block the inlet and prevent flows from entering the raingarden.

In these systems it does not appear that the construction stage has caused significant impact on the rain gardens. However this *may* become more evident once the raingardens are working and signs of construction impacts may start to appear (e.g. clogging of the filter media etc).

Weeds and litter are routine maintenance issues. We understand that routine maintenance has not been undertaken since the rain gardens were handed over to ACT government, however it is noted that in these systems there is not a high prevalence of weeds or litter in the rain gardens (possibly due to the lack of stormwater inflows) and it would not require significant effort to address this.

When we are able to review the design drawings, we will be able to comment further on other aspects of the design including depths, drainage arrangement, flushing points, finished levels, etc.

It is noted that the raingardens are significantly oversized relative to their catchments and this would have a positive impact on the robustness of these systems in Abena Ave.

Potential improvement options

There are three key recommendations for these streetscape systems:

- Lowering of the filter surface level to allow water to enter the raingarden and to provide more extended detention in the system. At best this lowering may potentially be required only at the inlet, but it may possibly be required across the whole raingarden to function effectively. This needs to be further resolved with site survey or similar.

- Reconfiguration of the inlet, to reflect the change in levels and to promote water entering into the rain garden and potentially also to increase the size of the inlet to reduce the risk of blockage due to single large pieces of litter and debris

- Consideration of a small pit and pipe to direct water into the raingarden for those systems which have no catchment. The new pit would be constructed upstream of the existing drainage pit

Finally it should be noted that similar systems were observed in the field on adjacent streets including Errol St and Fairfield St) and these issues were typical of the performance of these systems and these works would apply to these systems as well.

The rain gardens also need some simple routine maintenance such as weed removal, replanting and litter picking. As discussed above this would not require substantial effort.

In some cases, education of local residents could improve the performance of rain gardens. A well-informed resident should not dispose of waste in a rain garden and could even be inspired to undertake simple routine maintenance activities such as hand weeding and removing accumulated sediment from the inlet. Residents on this street have shown interest during site investigations and have asked questions about the systems during these site visits. These residents were supportive and enthusiastic about the raingardens and were interested in how they worked.