**Table 11: Summary of key findings from field performance indicators**

| Treatment system type | Indicators | Findings |
|---|---|---|
| Ponds | Sediment accumulation | Ponds are accumulating significant sediment loads; the quantity of sediment trapped in the ponds was typically higher than that predicted in MUSIC. Construction stage sediment loads could be a significant factor. |
| | Nutrient content in sediments | Ponds are accumulating significant loads of TP and TN, however TP and TN trapped in the ponds was typically lower than that predicted in MUSIC. In some cases it was significantly lower. |
| | Heavy metal content in sediments | Ponds are accumulating heavy metal loads, however sediment quality remains consistent with an ability to reuse materials on site or dispose of as “general solid waste” |
| | Wet weather sampling | Results were inconclusive; inflow concentration were relatively low in most events sampled |
| Wetlands | N/A | Without any good examples of functional stormwater treatment wetlands (i.e. extensive macrophyte systems with extended detention and a long residence time) in the ACT, this study has not been able to provide specific advice about the performance of wetlands in the ACT |
| Bioretention systems (rain gardens) | Filter media properties | The filter media used in the rain gardens tested at Crace and Forde is appropriate in terms of nutrient and heavy metal concentrations, however subsurface investigations revealed (potential) issues with filter media depth, lack of transition and drainage layers and use of geotextiles in the rain gardens. Further investigations are recommended to explore the extent of these issues |
| | Infiltration testing | Saturated hydraulic conductivity is generally consistent with guidelines |
| | Wet weather sampling | Results to date are inconclusive and issues noted above indicate that the systems monitored are not necessarily representative of well-functioning rain gardens |
| Swales and constructed waterways | Soil properties | High nutrient concentrations in the soil suggest that soils used in these systems are not appropriate and could be leaching nutrients |
| | Wet weather sampling | Results were inconclusive and issues noted above indicate that the systems monitored are not necessarily representative of well-functioning swales and waterways |
| GPTs | Analysis of cleanout data | GPTs are removing significant quantities of silt and debris from stormwater, however it is not clear how much of the TSS load this may represent. |
| | Wet weather sampling | Results showed some reduction in TSS concentrations in the GPT with a wet sump, however note risk of dry weather nutrient leaching from wet sump systems. Wet weather results were consistent with the expectation that GPTs would not significantly alter TP or TN concentrations during wet weather |

## 6.2 Process from coarse filter option development to concept design

The coarse filter options presented in Section 4 identify practical locations for treatment systems within the Tuggeranong catchment. These treatment locations are typically in open space areas under the jurisdiction of the ACT Government, and have limited constraints. Treatment options identified in the coarse filter and presented at the public consultation sessions reflected the general site characteristics and the potential for stormwater harvesting and reuse if there was a nearby sports field.

The process for developing the coarse filter options into concept designs sought to confirm the available treatment location, determine a feasible option based on the site constraints (slope), upstream catchment area draining to the proposed system and MUSIC modelling to determine the optimal type and size of treatment.

The process of the coarse filter option development to concept designs for stormwater treatment systems and riparian zones are outlined in the following two sections.

### 6.2.1 Typical concept design process for a stormwater treatment system

The typical concept design process for a stormwater treatment system is outlined in Figure 16. There are four main stages in the process, the key ones including an upstream catchment assessment, MUSIC modelling and the concept design.

The catchment assessment sought to determine the size, landuse and imperviousness of the catchment upstream of the proposed stormwater treatment system. The catchment assessment used a combination of methods including:

- Catchment size determined by GIS layers (contours, stormwater drainage and aerial photos) to identify the extent of the catchment area
- Catchment landuse determined by GIS layers (landuse zoning and aerial photos)
- Imperviousness determined by interrogation of aerial photos of the catchment to determine approximate roof, road, and other impervious and pervious percentages for different landuses within each catchment. Note that this assessment was done for each individual catchment, and is important to determining the pollution load generation within the MUSIC model.

Information from the community consultation process as well as inspections of each site were used to determine the area available for treatment. Factors which influenced the treatment system size included any active open space, services, slope, and trees.

The diversion of stormwater into the treatment system was determined by identifying the invert level of the stormwater inlet into the treatment system, and working back to find a connection to the invert of the drainage system with more than a 0.5% gradient between the stormwater diversion pit and the treatment system.

The invert of the stormwater system was typically not available for most sites and was determined based on surrounding invert levels and pipe diameters. Typically invert levels were determined to be at 2m depth below the surface level. Most diversions were less than 200m in length, however some sites did occasionally exceed this e.g. an 850m diversion at Tuggeranong Homestead.

When developing the concept designs, a range of options were considered at each site. However, most sites were constrained by available land (e.g. they are in an existing park, and have a large catchment above). In this situation, bioretention systems were selected as they are very effective at removing pollutants, which is a key criteria and weighting in the Multi-Criteria Analysis. Bioretention systems also require a smaller footprint as they do not have the larger embankments required of systems with open water (e.g. ponds and wetlands).

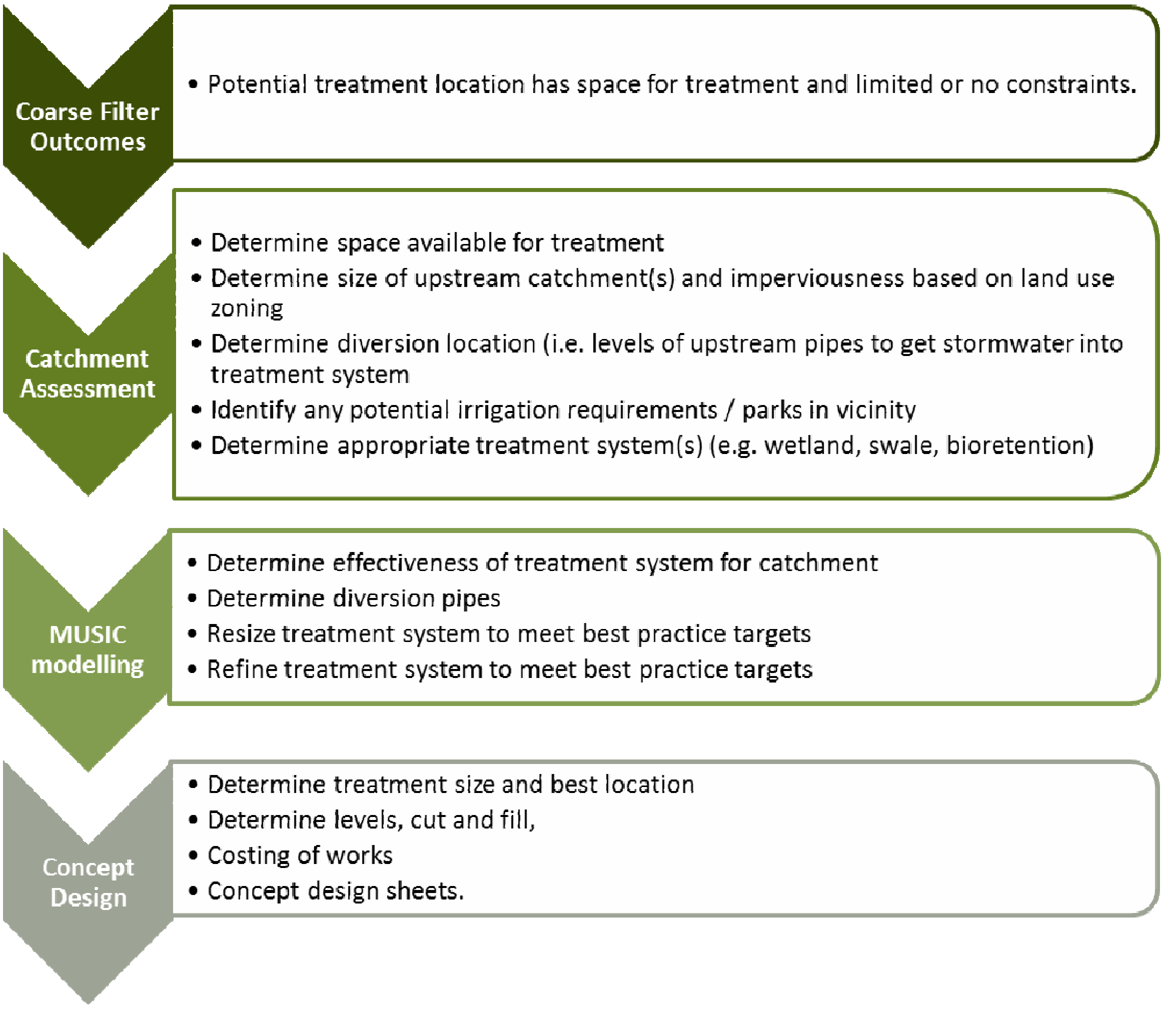


Figure 16. ***Overview of the concept design process for stormwater treatment systems***

Where there was available space, ponds or wetlands were selected. It needs to the noted that while ponds can be robust and are effective at removing sediments and nutrients, they are not as effective as bioretention systems at removing pollutants.

Stormwater harvesting was an additional component to treatment at sites where playing fields and/or irrigated parks were in proximity. There was a mixture of sites where water storage tanks already existed and sites where a storage pond or new tanks were proposed to meet the assumed irrigation demand. Figures on water consumption for irrigation were not available for most sites so an assumed irrigation rate of 5ML per hectare per annum was applied. For sites without consumption data, this assumed rate was applied to an area of irrigation that was determined by measuring visibly irrigated land shown in aerial imagery from Nearmap. Storage tanks and ponds also provide a small, additional measure of treatment to the primary mode of treatment.

MUSIC modelling tested the initial treatment concept designs to ensure best practice standards of treatment were met or exceeded. MUSIC modelling was also used to model the percentage of reuse demand met by a given storage type and volume, taking into consideration evaporation losses and further water treatment. Sensitivity testing of pipe sizing (optimised to meet best practice standards) also ensured the correct pipe size was costed and included in the design, as pipe diameters affect the depth of diversion invert levels.

Final concept designs were based on several criteria being met (e.g. Social, cultural and environmental) and engineering feasibility being confirmed. All elements of the design were costed to accurately reflect what is being proposed, including comprehensive calculations for cut and fill, pipe sizing and landscaping costs.

### 6.2.2 Typical concept design process for waterways

Waterways within the priority catchments can be broken down into three distinct categories, which require different design approaches to identify and quantify water quality improvement opportunities. These categories are:

- Creek Rehabilitation – consisting of projects revolving around the rehabilitation or stabilisation of eroding streams within and surrounding built up areas
- Creek Naturalisation – consisting of projects revolving around naturalisation of existing concrete lined channels in built up areas
- Riparian Revegetation – consisting of projects revolving around dedicated riparian revegetation programs along waterways in rural catchments outside of the urban areas.

Within the Tuggeranong catchment channel naturalisation has been identified as projects and are discussed in further detail below.

**Channel Naturalisation**

Creek naturalisation differs from creek rehabilitation in that it looks at naturalising existing concrete channels rather than stabilising eroding urban creeks. The process undertaken in assessing the potential to naturalise channels evolved primarily around determining the additional cross sectional area required of the rougher waterway to maintaining current flood capacity.

While maintaining flood capacity was a key driver in assessing the potential of options, it was only one of the drivers considered. These included:

- Maintaining flow and flood capacity
- Assessment of the impact of widening on existing infrastructure and services
- Considering waterway profiles that will enhance the surrounding ecological and habitat values
- Considering waterway profiles that will maintain existing community and stakeholder uses

Assessment of additional cross sectional width required was based on estimating the current channel capacity to top of bank by using the Manning's channel equation. Input values such as geometry data were derived from 1 m contour data and Nearmap elevation data. Roughness parameters were based on past experience and industry standards. Sizing of the additional naturalised waterway was undertaken by varying the roughness parameter to represent a more rough vegetated channel and cross section until currently capacity was matched. Waterway grade and total depth was maintained as these points were considered fixed to existing tie-in points upstream and downstream.

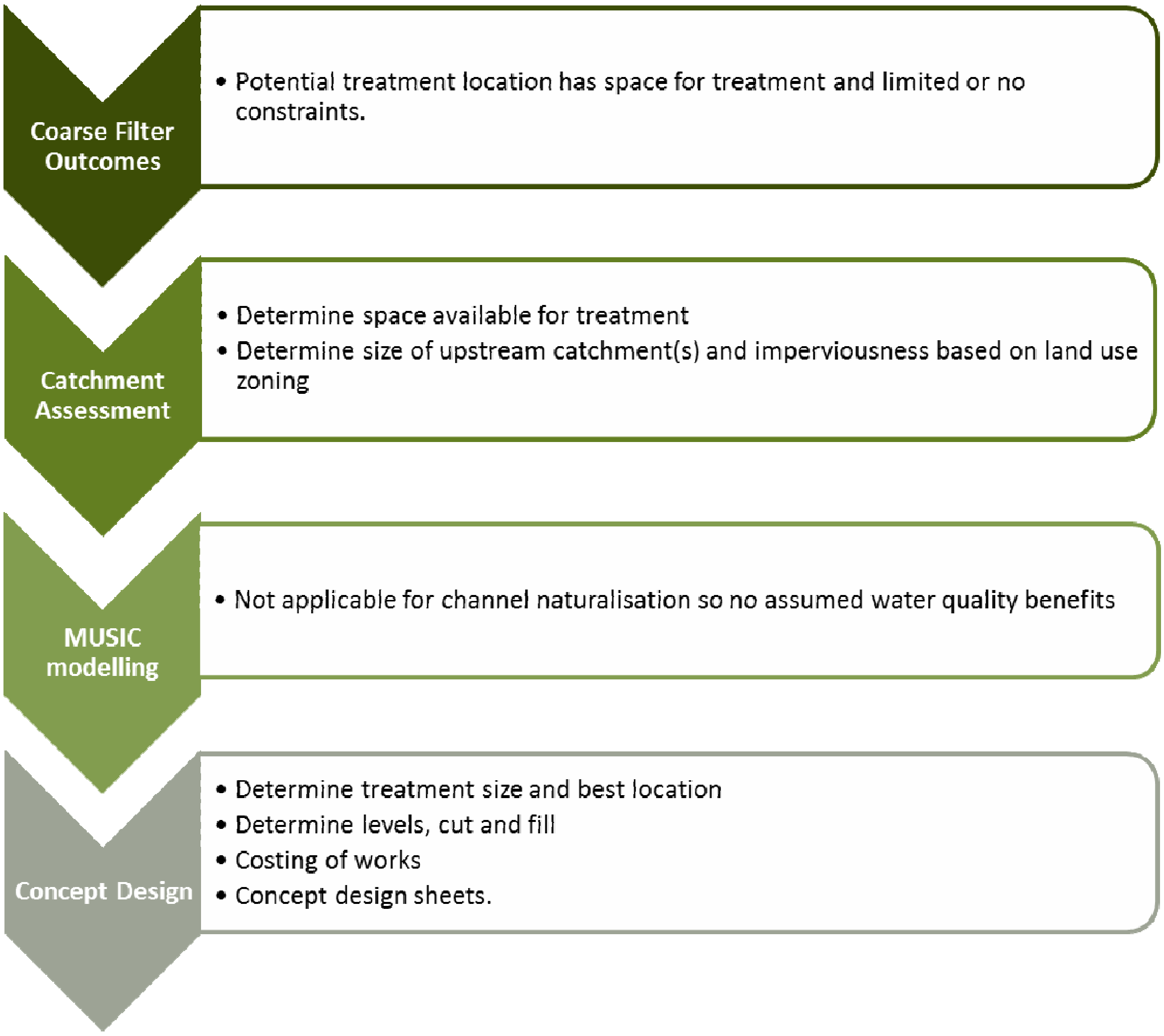


**Figure 17.** *Overview of concept design process for channel naturalisation*

# 7 Final sites and infrastructure options

The results of the coarse filter process and community consultation were used refined the short list to 31 sites for infrastructure concept design development (Table 12 and Figure 18). At several sites there were multiple concepts developed such that in total there are 50 concepts presented in Table 12 and Appendix B. As per the coarse filter results, these maintained a mixture of opportunities at sports and recreational reserves, road side reserves, parks and playground reserves, river corridor reserves, rural land leases and existing WSUD assets.

**Table 12. Infrastructure concept design sites for the Tuggeranong catchment**

| Site ID | Option description |
|---|---|
| LT001 | Wetlands (catchment area 60.3 ha) |
| LT002 | Swale and bioretention (catchment area 102.2 ha) |
| LT003 | Bioretention & reuse (existing tanks) (catchment area 114.4 ha) |
| LT003W | Wetland (catchment area 114.4 ha - 30% of flow treated) |
| LT004 | Bioretention & reuse (existing tanks) (catchment area 58.09 ha) |
| LT005 | Swale and bioretention & reuse (existing tanks) (catchment area 75.1 ha) |
| LT006 | Bioretention (catchment area 82.6 ha) |
| LT006W | Wetland (catchment area 36.2 ha - 26% of flow treated) |
| LT007A | Bioretention (catchment area 42.2 ha) |
| LT007B | Bioretention (catchment area 76.4 ha) |
| LT007BW | Wetland (catchment area 76.4 ha - 16% of flow treated) |
| LT008 | Bioretention, swale & storage pond for reuse (catchment area 70.9 ha) |
| LT009 | Bioretention (catchment area 33.2 ha) |
| LT010A | Increase extended detention at Upper Stranger Pond to 0.5 m and 72 hour detention time. |
| LT010B | Remove sediment from Upper Stranger Pond (catchment area 397.1 Ha) |
| LT010C | Offline bioretention at Upper Stranger Pond & reuse (catchment area 357.0 ha, 2 cumec diversion) |
| LT010CW | Offline wetland at Upper Stranger Pond & reuse (catchment area 357.0 ha, 0.15 cumec diversion) |
| LT011A | Increase extended detention at Isabella Pond to 0.5 m and 72 hour detention time. |
| LT011B | Remove sediment from Isabella Pond (catchment area 4494.2 Ha) |
| LT011C | Detention, remove sediment and wetland at Isabella Pond |
| LT012 | Conversion of concrete channel to a swale |
| LT013 | Bioretention (catchment area 31.2 ha) |
| LT014 | Bioretention and water reuse (catchment area 77.3 ha) |
| LT014W | Wetland and water reuse (catchment area 77.3 ha, 0.1 cumec diversion (32% of flows treated)) |
| LT015 | Bioretention (catchment area 90.8 ha) |
| LT016 | Bioretention (catchment area 30.87 ha) |
| LT017 | Bioretention and water reuse (catchment area 165.8 ha) |
| LT017W | Wetland (catchment area 165.8 ha - 13% of flow treated) |
| LT018 | Bioretention (catchment area 137.1 ha) |
| LT018W | Wetland (catchment area 137.1 ha - 28% of flow treated) |
| LT019 | Conversion of concrete channel to a vegetated swale |

| Site ID | Option description |
|---|---|
| LT021A | Bioretention (catchment area 35.3 ha) |
| LT021B | Bioretention (catchment area 28.3 ha) |
| LT022 | Bioretention and storage pond for water reuse (catchment area 23.36 ha) |
| LT023 | Bioretention (catchment area 135.7 ha - 87% of flows treated) |
| LT023W | Wetland (catchment area 135.7 ha - 17% of flow treated) |
| LT024 | Wetlands (catchment area 13.86 ha) |
| LT025A | Bioretention (catchment area 1182 ha [368 ha urban] - 53% of flows treated) |
| LT025B | Wetland (catchment area 8.7 ha) |
| LT025C | Restoration of creek flow (baseflow from Tuggeranong Creek) - to be considered with LT025A or LT025B. |
| LT027 | Pond (urban catchment area 65.9 ha, 0.4 cumec diversion allows 59% of flows to system) |
| LT028 | Bioretention and wetland located on former landfill (catchment area 86.0 ha) |
| LT028W | Wetland on former landfill (catchment 86ha, 0.7 cumec diversion, diverting 79% of flows to wetland) |
| LT029 | Bioretention (catchment area 113.1 ha) |
| LT029W | Wetland (catchment area 113.1 ha, 0.1 cumec diversion (28% of flows treated)) |
| LT030 | Bioretention and reuse (existing tanks) (catchment area 285.6 ha - 62% of flows treated) |
| LT030P | Pond and reuse (existing tanks) (catchment area 285.6 ha - 28% of flows treated) |
| LT031 | Bioretention (catchment area 85.83 ha) |
| LT031W | Wetland (catchment area 85.83 ha - 26% of flows treated) |
| LT032 | Conversion of concrete channel (Tuggeranong Creek) to a swale |

Summaries of each of the concept designs are presented below.

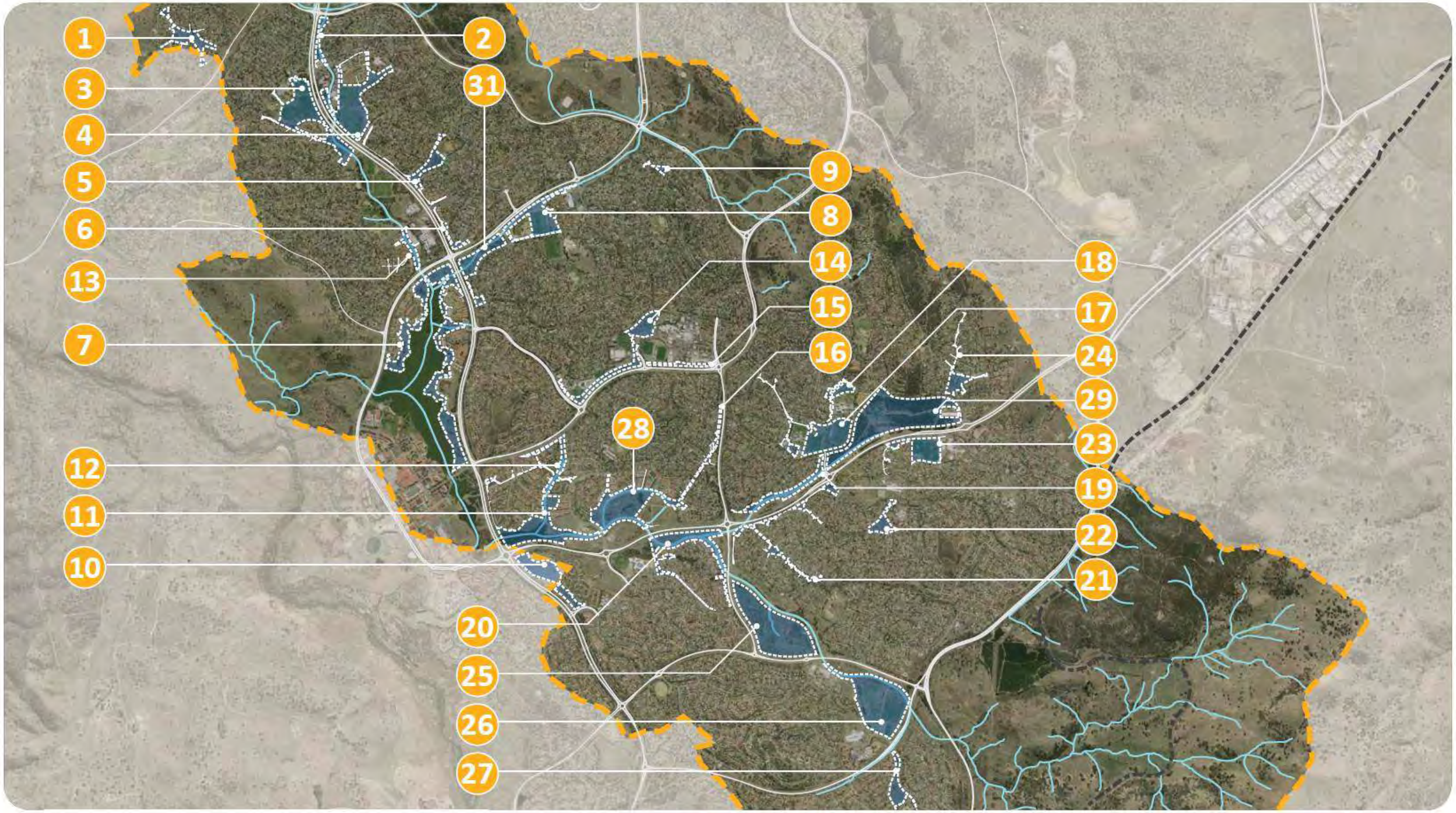


**Figure 18:** *Infrastructure concept design sites in the Tuggeranong catchment (refer Table 12).*

## 7.1 Descriptions of infrastructure concepts developed

The following concept design descriptions refer to plans and further detail provided for each site in Appendix B.

### 7.1.1 LT001-Wetlands (catchment area 60.3 ha)

Two wetland systems are proposed at Site 1, to treat a catchment area of approximately 74.3 hectares, of which 23.3 hectares are urban (excludes rural and bushland). The total macrophyte zone area is approximately 3,900 $m^2$, which is approximately 1.7% of the urban catchment area. Two wetlands are proposed, which have each been sized to treat separate catchments. Using two wetlands helps to minimise cut and fill across the sloping site, and to accommodate existing underground services between the wetland cells. The second wetland (system B) has an enlarged inlet/sediment basin to maximise use of the available space in that cell as there is limited space for the macrophyte zone downstream.

The two wetland systems have been positioned to avoid removal of existing trees. The larger landscaped area around the wetlands would involve understorey planting beneath existing trees. This landscaped area shown is the ideal shape and size for amenity improvement (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area).

The wetlands system is located in a highly visible site in an open space corridor. The area is currently used for passive recreation. The wetlands will add to diversity of recreational space (e.g. seating, bird watching, nature appreciation), while leaving areas open for existing uses (e.g. dog walking). Vehicular access for maintenance is provided by existing concrete paths and additional paved access tracks into each sediment basin.

### 7.1.2 LT002-Swale and bioretention (catchment area 102.2 ha)

A large swale with accompanying bioretention system are proposed at Site 2, to treat a catchment area of approximately 102.2 hectares, of which 26.1 hectares is urban. The total treatment area for the swale and bioretention system shown in this plan is approximately 4,285 $m^2$, which is approximately 1.6% of the urban catchment area. The swale proposed lies in an area that is an existing overland flow path. A swale is most appropriate in this location as the site is currently shaped as a swale and other treatment systems would be impacted by scour in the high flow events. It is proposed to divert flows into the swale to treat stormwater. A bioretention system is proposed offline of the overland flow path.

These two treatment components have been positioned to minimise removal of existing trees. To maximise the size and shape of the swale and storage pond five large trees have been proposed for removal. The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees (the costed amount is for a smaller area – 30% of the bioretention area). The construction of the treatment train is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.3 LT003-Bioretention & reuse (existing tanks) (catchment area 114.4 ha)

Two large catchments drain south through Kambah District Playing Fields where a network of large stormwater pipes meet south of the fields near Drakeford Drive. The catchment that would be diverted for treatment at this proposed bioretention system totals 114.4 hectares, of which 97.6 is urban (excludes rural and bushland).

It is proposed these two catchments have diversions that run on, with the total length from the first diversion to the bioretention system 530 m long. It is necessary for the diversion pipe to cut across the fields (rather than around) to reduce the overall length of diversion and to maximise the available fall across the site. The bioretention system is relatively large and it is proposed to have a tiered system with two levels to allow cascading in high flows. A pump will transfer treated flows from the base of the bioretention system to the storage tanks that exist onsite already. This will provide 22.87 ML/yr for irrigation.

The existing cycleway will not be affected and an additional walking path around the western side of the bioretention system adds to the amenity of the site. The landscaped area shown in the image is the ideal shape and size for development (the costed amount is for a smaller area – 30% of the bioretention area).

### 7.1.4 LT003W-Wetland (catchment area 114.4 ha - 30% of flow treated)

A 46 hectare catchment (all urban) drains south through Kambah District Playing Fields where a network of large stormwater pipes meet south of the fields near Drakeford Drive. A proposed wetland for this site is undersized for this sized catchment and hence a diversion rate of 50 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 42.3 ML/yr of the total 141 ML/yr flowing from the catchment to the wetlands for treatment. Due to the mild slope a longer diversion of 210 m is required.

Tree removal is required in order to get sufficient space for the treatment system however it is expected that with the addition of the wetland and associated landscaping the overall ecosystem quality will improve.

The existing cycleway will not be affected and an additional walking path around the wetland and between the sediment basins will add to the amenity of the site. The landscaped area shown in the image is the idealised shape and size for development (the costed amount is for a smaller area – 30% of the total wetland area). Access will be from Chirnside Circuit where a 15 m track will be paved to join the existing path for access to the site. An additional track into the sediment basin is for maintenance.

### 7.1.5 LT004-Bioretention & reuse (existing tanks) (catchment area 58.09 ha)

A pair of bioretention systems are proposed at Site 4. There are two separate catchments upstream of Kambah District Playing Fields (east) totalling 58.1 hectares, of which 29.3 hectares is urban (excludes rural and bushland). Bioretention System A would have a catchment diverted under Marconi Crescent which would require underboring at the bridge/footpath underpass (at contour 614 m AHD, on the northside of the bridge). This system would have treated flows conveyed downstream to the four existing storage tanks onsite via a small pipe. High flows at this system would be diverted to the stormwater pipe running parallel to the system. This would be a catchment transfer as this is not the same pipe it is being diverted from. Bioretention System B treats a smaller catchment (9.7 ha).

The two bioretention systems are positioned between two footpaths in a highly visible site, amongst a play area and bowling nets. This location would require removal of one tree and one shrub though it is expected construction of the treatment system would improve the ecosystem value through increased diversity in habitat. This landscaped area shown in the image is the ideal shape and size for amenity improvement (note the costed amount is for a smaller area – 30% of the bioretention area). The bioretention systems and associated landscaping will add to diversity of recreational space (e.g. seating, bird watching, nature appreciation), while leaving grass areas for existing uses (e.g. dog walking, playing). Access for maintenance would be from the existing paths and additional connecting track from the Lascelles Circuit.

### 7.1.6 LT005-Swale and bioretention & reuse (existing tanks) (catchment area 75.1 ha)

A swale with accompanying bioretention system are proposed at Site 5, to treat a catchment area of approximately 78.1 hectares, of which 40.9 hectares is urban. The total treatment area for the swale and bioretention system shown in this plan is approximately 2,459 $m^2$, which is approximately 0.6% of the urban catchment area. A swale is most appropriate in this location given the site's long linear nature. It is proposed to divert flows into the swale and subsequently into the bioretention system to treat stormwater.

These two treatment components have been positioned to minimise removal of existing trees. To maximise the size and shape of the swale and bioretention system four large trees have been proposed for removal. The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees (the costed amount is for a smaller area – 30% of the total treatment area). The construction of the treatment train and associated landscaping is expected to improve habitat diversity and amenity.

### 7.1.7 LT006-Bioretention (catchment area 82.6 ha)

A large bioretention system is proposed to treat a single, large upstream catchment of 72.9 hectares, of which 61.6 hectares is urban (excludes rural and bushland). There is an additional 9.75 hectare catchment (all urban) that could enter the system on the eastern side of the scheme, through a leaky pipe in the bioretention system (the upstream invert levels are too deep for daylighting).

A moderately visible site with apparent foot traffic across the site (evidence of a well worn path from the intersection to the local residential street across the site), this an ideal site for development due to the large open area and potential lack of use. Its proximity to a busy intersection would result in an improved landscape and environment within the buffer area.

There are two small sewer lines (150 mm) and an electricity line that lie within the bounds of the bioretention system which would need to be investigated at the detailed design stage to establish depths and potential for movement if required. The stormwater line that runs through the western half of the system has an upstream invert level of 578 m AHD, which would be deep enough to build over without impact.

### 7.1.8 LT006W-Wetland (catchment area 36.2 ha - 26% of flow treated)

A 36.2 hectare catchment (all urban) drains south along Athllon Drive where a network of large stormwater pipes meet at the intersection with Drakeford Drive. A proposed wetland for this site is undersized for this catchment and hence a diversion rate of 40 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 35 ML/yr of the total 132 ML/yr flowing from the catchment to the wetlands for treatment.

The existing stormwater pipes and services constrain the shape of the wetland with the sediment basin long and narrow – necessary to get sufficient depth and volume for sedimentation.

A moderately visible site with apparent foot traffic across the site (evidence of a well worn path from the intersection to the local residential street across the site), this an ideal site for development due to the large open area and potential lack of use. Its proximity to a busy intersection would result in an improved landscape and environment within the buffer area.

Note the area shown for landscaping is the ideal size for amenity improvement, the costed amount is for a smaller area – 30% of the total wetland area.

### 7.1.9 LT007A-Bioretention (catchment area 42.2 ha)

At the north end of Lake Tuggeranong there is available land for a bioretention system to treat 42.2 hectares of urban catchment. Two diversions will direct flow into the 1,400 sq.m bioretention system prior to discharge to Lake Tuggeranong itself.

The landscaped area shown in the image is the ideal shape and size for amenity improvement (note the costed amount is for a smaller area – 30% of the bioretention area). The bioretention systems and associated landscaping will add to diversity of recreational space (e.g. seating, bird watching, nature appreciation), while leaving areas open for existing uses (e.g. dog walking, commuting).

The location of the bioretention system was chosen to maximize the size of the system and would be constructed over an existing path. The existing concrete path would be realigned on the eastern side of the system, through trees and open space. The concrete path would provide access during construction and maintenance periods. Entry is from De Little Circuit 100 m south of the site.

### 7.1.10 LT007B-Bioretention (catchment area 76.4 ha)

A bioretention system treatment option has been developed for Site 7B. This option will have an incoming catchment of 76.4 hectares (all urban). In order to capture this area a diversion is required that crosses Drakeford Drive, using underboring for 70 m of the total 160 m diversion.

The bioretention system has been positioned to make use of a relatively large, open space adjacent to the lake. There are approximately 4 mature trees that require removal to maximise development of this space. An additional 30 juvenile trees and shrubs also require removal. The ideal landscaping area shown around the bioretention system would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area). The construction of the bioretention system is expected to improve ecosystem value through increased diversity in habitat.

The bioretention system is located in a highly visible site in an open space reserve. The area is currently used for passive recreation and a regional cycle path which would have the original 70 m of path replaced with a boardwalk that passes through the centre of the system. This existing path would also provide access to the site for construction. Entry is from De Little Circuit 100 m south of the site.

### 7.1.11 LT007BW-Wetland (catchment area 76.4 ha - 16% of flow treated)

A wetland treatment option has been developed for Site 7BW. This option will have an incoming catchment of 76.4 hectares (all urban). In order to capture this area a diversion is required that crosses Drakeford Drive, using underboring for 70 m of the total 130 m diversion. The wetland is undersized for this sized catchment and hence a diversion rate of 40 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 41.2 ML/yr of the total 261 ML/yr flowing from the catchment.

The wetland system has been positioned to make use of a relatively large, open space adjacent to the lake. There are approximately 5 mature trees that require removal to maximise development of this space. An additional 38 juvenile trees and shrubs also require removal. The landscaping area shown in the image is the ideal size for amenity improvement and would involve understorey planting beneath existing trees. The construction of the wetland is expected to improve ecosystem value through increased diversity in habitat.

The wetland system is located in a highly visible site in an open space reserve. The area is currently used for passive recreation and a regional cycle path which would be realigned around the wetland and between the sediment basins in order to maximize the treatment area. This existing path would also provide access to the site for construction. Entry is from De Little Circuit 100 m south of the site.

### 7.1.12 LT008-Bioretention, swale & storage pond for reuse (catchment area 70.9 ha)

A large swale with accompanying bioretention system and pond are proposed at Site 8, to treat a catchment area of approximately 70.9 hectares (all urban). The total treatment area for the swale and bioretention system shown in this plan is approximately 7,300 $m^2$, which is approximately 1% of the catchment area. The swale proposed lies in an area that is an existing overland flowpath. A swale is most appropriate in this location as it is currently shaped as a swale and other treatment systems would be impacted by scour in the high flow events. It is proposed to divert low flows into the swale to treat stormwater in the smaller events. A bioretention system is proposed offline of the overland flow path and low flow treatment swale. The upstream catchment will be diverted to the system. Any overflows from the bioretention system would flow into the swale and treated flows would enter via subsoil drainage. The final part of the treatment train is a storage pond. This will further polish the partially treated stormwater as well as store water for subsequent reuse. A submersible pump will pump water back to the existing storage tanks on site at Wanniassa Playing Fields for irrigation.

These two treatment components have been positioned to minimise removal of existing trees. To maximise the size and shape of the swale and storage pond two trees have been proposed for removal. The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees. The construction of the treatment train is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.13 LT009-Bioretention (catchment area 33.2 ha)

Two catchments drain through a reserve between Longmore Crescent and Sainsbury Street. The catchments that would be diverted for treatment at this proposed bioretention system totals 33.2 hectares, of which 30.6 is urban (excludes rural and bushland). The major catchment would be diverted on the eastern side of Sainsbury Street and crosses 5 services and two additional stormwater lines. If this catchment is too costly or too difficult to divert the second, minor catchment of 6.1 hectares could be the sole diversion and the corresponding bioretention area be reduced. This second catchment is diverted on the southern side of the reserve.

Due to the shape of the site it is proposed the bioretention system have a tiered system over three levels to allow cascading in high flows. The minor catchment would enter at the lowest tier of 630.9 m AHD, nearest the outlet – this will help spread the incoming flow across more of the bioretention surface. The larger landscaping area identified around the proposal is the ideal size to improve amenity, and would involve understorey planting beneath existing trees (the costed amount is for a smaller area – 30% of the bioretention area).

Apart from the number of services near the site it is relatively unconstrained, requiring no tree removal.

### 7.1.14 LT010A-Increase extended detention at Upper Stranger Pond to 0.5 m and 72 hour detention time

Upper Stranger Pond captures stormwater runoff from a large catchment including Isabella Plains and flows into the southern inlet of Isabella Pond. As with the other ponds in the area the pond was built in the 1980s when Tuggeranong was constructed.

Three improvement options have been considered for Upper Stranger Pond including increasing extended detention (currently 0.0 m) to 0.5 m and retention time to 72 hours. This would be achieved by modifying the existing outlet pipe. It is noted that increasing the extended detention will decrease the water surface area and therefore decrease the volume of the pond. As such, the works also include regrading the banks to 1:6 slope and revegetating the pond edge.

Increasing the extended detention is expected to remove an additional 4,400 kg of TSS per year and 5 kg of phosphorus per year. There is no change in the removal of TN or gross pollutants.

### 7.1.15 LT010B-Remove sediment from Upper Stranger Pond (catchment area 397.1 Ha)

Upper Stranger Pond captures stormwater runoff from a large catchment including Isabella Plains and flows into the southern inlet of Isabella Pond. As with the other ponds in the area the pond was built in the 1980s when Tuggeranong was constructed.

Three improvement options have been considered for Upper Stranger Pond including removing the sediment which has accumulated in the pond. Based on previous investigations undertaken (Ecowise, 2009), it is estimated that approximately 10,620 $m^3$ of sediment has accumulated in Upper Stranger Pond over its 30 year life span. It is anticipated that a portion of this sediment is attributed to construction/development of the upstream catchment. Removing accumulated sediment will 'reset' the pond.

It is proposed to relocate the sediment to the south of the pond and landscape this area. Further assessment would need to be undertaken to ensure sediment is suitable for reuse (i.e in terms of potential contamination).

### 7.1.16 LT010C-Offline bioretention at Upper Stranger Pond & reuse (catchment area 357.0 ha – 72% of flow treated)

A large bioretention system is proposed at Site 10C, to assist in treating a catchment area of approximately 357.0 hectares, of which 301.0 hectares is urban. The total treatment area for the bioretention system shown in this plan is approximately 5,700 $m^2$, which is approximately 0.19% of the urban catchment area. The bioretention system has been sized to meet best practice standards in conjunction with Upper Stranger pond which has a surface area of approximately 42,480 sq.m. It is proposed that low flows are diverted into the bioretention system and then released into Upper Stranger Pond.

The treatment system has been positioned to minimise removal of existing trees (no mature trees require removal). The larger landscaping area identified around the treatment area would involve understorey planting beneath existing trees. The construction of the treatment train is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.17 LT010CW-Offline wetland at Upper Stranger Pond & reuse (catchment area 357.0 ha – 14% of flow treated)

A wetland system is proposed at Site 10CW, to assist in treating a catchment area of approximately 357.0 hectares, of which 301.0 hectares is urban. The total macrophyte treatment area for the wetland, as shown in this plan is approximately 4,566 $m^2$, which is approximately 0.15% of the urban catchment area. The wetland system has been sized to meet best practice standards. It is noted that only low flows will be diverted to the wetland system (i.e 14% of flows).

The treatment system has been positioned to minimise removal of existing trees (no mature trees require removal) and leave a large area of open space for activities such as dog-walking and kick-around sports. The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees. The construction of the wetland is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.18 LT011A-Increase extended detention at Isabella Pond to 0.5 m and 72 hour detention time

Isabella pond was built in the 1980s to improve treat water draining to Lake Tuggeranong. Tuggeranong Creek is the main inlet into the pond and there are also smaller tributaries which enter Isabella Pond from the north and south. The main and northern inlets are pre-treated in GPTs. The southern tributary is pre-treated in Upper Stranger Pond.

Three improvement options have been considered for Isabella Pond including increasing extended detention (currently 0.21 m) to 0.5 m and retention time to 72 hours. This would be achieved by installing a new outlet pipe (300 mm diameter) to bypass the weir. It is noted that increasing the extended detention will decrease the water surface area and therefore decrease the volume of the pond. As such, the works also include regrading the banks to 1:6 and revegetating the pond edge.

Increasing the extended detention is expected to remove an additional 30,000 kg of TSS per year and 70 kg of phosphorus per year. There is no change in the removal of TN or gross pollutants.

### 7.1.19 LT011B-Remove sediment from Isabella Pond (catchment area 4494.2 Ha)

Isabella pond was built in the 1980s to improve treat water draining to Lake Tuggeranong. Tuggeranong Creek is the main inlet into the pond and there are also smaller tributaries which enter Isabella Pond from the north and south. The main and northern inlets are pre-treated in GPTs. The southern tributary is pre-treated in Upper Stranger Pond.

Three improvement options have been considered for Isabella Pond including removing the sediment which has accumulated in the pond. Based on previous investigations undertaken (Quantitative Assessment Report, Alluvium 2015), it is estimated that approximately 22,260 $m^3$ of sediment have accumulated in Isabella Pond over its 30 year life span. It is anticipated that a portion of this sediment is attributed to construction/development of the upstream catchment. Removing accumulated sediment will 'reset' the pond.

It is proposed to remove the sediment offsite. However based on preliminary results (Quantitative Assessment Report, Alluvium 2015), sediment concentrations are below the NEPM HILs and may be suitable for reuse/landscaping.

### 7.1.20 LT011C-Detention, remove sediment and wetland at Isabella Pond

Isabella pond was built in the 1980s to improve treat water draining to Lake Tuggeranong. Tuggeranong Creek is the main inlet into the pond and there are also smaller tributaries which enter Isabella Pond from the north and south. The main and northern inlets are pre-treated in GPTs. The southern tributary is pre-treated in Upper Stranger Pond.

Three improvement options have been considered for Isabella Pond including increasing extended detention (currently 0.21 m) to 0.5 m and retention time to 72 hours. This would be achieved by installing a new outlet pipe (300 mm diameter) to bypass the weir. It is noted that increasing the extended detention will decrease the water surface area and therefore decrease the volume of the pond. As such, the works also include regrading the banks to 1:6 and revegetating the pond edge.

Increasing the extended detention is expected to remove an additional 30,000 kg of TSS per year and 70 kg of phosphorus per year. There is no change in the removal of TN or gross pollutants.

### 7.1.21 LT012-Conversion of concrete channel to a swale

A concept plan has been developed for Site 12 to naturalise a section of concrete channel between Corlette Crescent, Monash and Isabella Pond. An indicative cross-section is shown on the following page. Preliminary flow and velocity estimates indicate that the naturalised channel could be converted to a vegetated swale to provide some treatment of stormwater prior to entering Isabella Pond. It is proposed that the swale would occupy the area currently occupied by the concrete channel and slightly widened (from 3.2 to 6.8 m).

It is expected that the creek naturalisation will improve ecosystem value through increased diversity in habitat.

### 7.1.22 LT013-Bioretention (catchment area 31.2 ha)

Site 13 treats two residential catchments with a combined area of 31.2 hectares (all urban) in a bioretention system. The major catchment that drains from the north requires a 220 m diversion from O'Halloran Circuit (at contour 579.5 m AHD) and would require repaving of the concrete foot/bikepath that runs through this drainage corridor – to avoid excessive removal of trees the diversion would be under or near the existing footpath. The second catchment would be diverted at contour 579.2 m AHD, near Jenke Circuit.

The location of the bioretention system makes use of an open area though it still requires removal of trees, approximately 2 mature trees (> 10 m tall) and 11 juvenile trees would be removed to make space for this system. An existing footpath would also be replaced by a boardwalk that crosses the system. Along with seating and landscaping it is expecting the amenity of this area will be improved as the space appears to be currently underutilised.

Access to the site is via a new 3 m wide concrete path from Jenke Circuit to the southern end of the site where it meets existing paths. The larger landscaping area identified around the proposal is the ideal area for improving amenity, and would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the bioretention area).

### 7.1.23 LT014-Bioretention and water reuse (catchment area 77.3 ha)

A large bioretention system is proposed at Site 14, to assist in treating a catchment area of approximately 77.3 hectares, of which is entirely urban. The total treatment area for the bioretention system shown in this plan is approximately 2,696 $m^2$, which is approximately 0.35% of the catchment area. The bioretention system has been sized to meet best practice standards.

The treatment system has been positioned to minimise removal of existing trees. To maximise the size and shape of the bioretention system two large trees have been proposed for removal. The larger landscaping area identified around the proposal is the ideal area, and would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area). The construction of the bioretention system is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.24 LT014W-Wetland and water reuse (catchment area 77.3 ha - 32% of flow treated)

A wetland system is proposed at Site 14W, to assist in treating a catchment area of approximately 77.3 hectares, which is entirely urban. The total macrophyte treatment area as shown in this plan is approximately 2,040 $m^2$, which is approximately 0.26% of the catchment area. The wetland system has been sized to meet best practice standards. It is noted that only low flows will be diverted to the wetland system (i.e 32% of flows).

The treatment system has been positioned to minimise removal of existing trees. To maximise the size and shape of the wetland system six large trees have been proposed for removal. The larger landscaping area identified around the proposal is the ideal size for amenity improvement and would involve understorey planting beneath existing trees (note the costed amount is for a smaller landscaped area – 30% of the bioretention area). The construction of the wetland system is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.25 LT015-Bioretention (catchment area 90.8 ha)

A tiered bioretention system is proposed for Site 15, to treat stormwater flows from a 90.8 hectare catchment, of which 60.7 hectares is urban (excludes rural and bushland). Because of the deep stormwater invert levels and mild slope of the flow path the diversion has to be taken 400 m upstream of the site, at the intersection of Ashley Drive and Erindale Drive, at contour 610.75 mAHD.

To address the level change over the site the 3,200 sq.m bioretention system is in four cells, separated by weir structures. Flows from the top cell will cascade into the lower cells during high flows.

The location of this scheme is within an area that would likely be an overland flow path for high stormwater flows, and thus the bulk of the system has been positioned 'offline' to prevent scouring in high flows. Only minimal landscaping has been proposed here due to the area being a likely overland flowpath.

Approximately 15-16 trees of various heights would require removal at this site. There is a well-worn path across the site that has been replaced by an 80 m boardwalk across the bioretention system.

### 7.1.26 LT016-Bioretention (catchment area 30.87 ha)

There is a drainage corridor that runs parallel to Ashley Drive. A diversion is proposed 170 m upstream from an open space within this corridor. The need for a diversion at such a distance is due to grade and depth of existing stormwater levels forbidding daylighting closer to the site. A 30.9 hectare catchment (all urban) would be treated in a 1,100 sq.m bioretention system.

Due to limited space the bioretention system would be situated around the existing stormwater drain with the stormwater pipes sitting within the filter media. This allows for a better surface area to perimeter ratio.

No trees require removal with this design. The landscaped area shown in the image is the ideal area to allow maximum improvement in amenity. To maintain the existing pathway through this site a 70 m boardwalk would be built to replace the original path. A 30 m access track is proposed for the north end of the system, near the GPT.

### 7.1.27 LT017-Bioretention and water reuse (catchment area 165.8 ha)

A large catchment of 165.8 hectares drains through the Gowrie District Playing field, of which 120.2 hectares is urban catchment (excludes rural and bushland). There is an open space to the south west of the two ovals which is suitable for a tiered bioretention system. A 210 m diversion is required to reach the site due to the low grade and deep stormwater invert levels. The diversion is located on the main stormwater trunk running between the fields, at contour 612.5 mAHD.

Treated water will flow to the two new 250 kL storage tanks buried underneath the bioretention systems to maximize the filter area of the treatment system and reduce the visual impact of the tanks. Tank overflows will be diverted to an adjacent stormwater pipe and a pump and rising main will transfer treated water for reuse on site at the playing fields. The header tank location is assumed to be near the building situated between the two ovals.

The outlet pipe from the bioretention system would connect to an existing arm that feeds back into the primary stormwater pipe. If the diameter (375 mm Ø) is insufficient, the outlet pipe would need to be extended by an additional 70 m.

### 7.1.28 LT017W-Wetland (catchment area 165.8 ha - 13% of flow treated)

A large catchment of 165.8 hectares drains through the Gowrie District Playing field, of which 120.2 hectares is urban catchment (excludes rural and bushland). There is an open space to the south west of the two ovals which is suitable for a wetland system. The proposed wetland for this site is undersized for this catchment and hence a diversion rate of 50 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 53 ML/yr of the total 420 ML/yr flowing from the catchment to the wetlands for treatment. A

200 m diversion is required to reach the site due to the low grade and deep stormwater invert levels. The diversion is located on the main stormwater trunk running between the fields, at contour 611.0 m AHD.

The gravity maintenance pipe and high flow bypass from the sediment basin would connect to an existing arm that feeds back into the primary stormwater pipe. If the diameter (375 mm Ø) is insufficient, the pipe would need to be extended by an additional 70 m. The outlet pipe at the end of the wetland drains to a different stormwater pipe on the western boundary of the site and would involve a catchment transfer.

Note the area shown for landscaping is the ideal size for amenity improvement, the costed amount is for a smaller area – 30% of the total wetland area.

### 7.1.29 LT018-Bioretention (catchment area 137.1 ha)

Site 18 is located in Hannah Community Park where a 137 hectare catchment drains through the centre of the park, 91.4 hectares of which is urban catchment (excludes rural and bushland). It is proposed a large bioretention system be installed here to treat such a large catchment. It would be a tiered bioretention system with two elevations making use of the slope on site to minimise excavation etc.

Approximately 10 trees would require removal (8 juvenile, 2 mature) to accommodate this system, however due to the associated landscaping it is expected there will be an overall improvement in the ecosystem and biological diversity. Paths and seating will also improve the amenity of the site. The path that currently runs north-south through the site would be replaced by a boardwalk.

There will be an access track installed that connects Weathers Street to the bioretention system and access to the diversion point can be made via the existing 2.5 m wide bike path from Rickard Place to the north.

### 7.1.30 LT018P-Pond (catchment area 137.1 ha - 28% of flow treated)

Site 18P is located in Hannah Community Park where a 137 hectare catchment drains through the centre of the park, 91.4 hectares of which is urban catchment (excludes rural and bushland). A proposed pond for this site is undersized for this catchment and hence a diversion rate of 110 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 92 ML/yr of the total 328 ML/yr flowing from the catchment to the pond for treatment.

Approximately 10 trees would require removal (8 juvenile, 2 mature) to accommodate the pond, however due to the associated landscaping it is expected there will be an overall improvement in the ecosystem and biological diversity. Paths and seating will also improve the amenity of the site. The path that currently runs north-south through the site will not be affected and will have an additional rock path that connects it to the eastern side of the pond for viewing and seating.

There will be an access track installed that connects Weathers Street to the pond and access to the diversion point can be made via the existing 2.5 m wide bike path from Rickard Place to the north.

### 7.1.31 LT019-Conversion of concrete channel to a vegetated swale

A concept plan has been developed for Site 19 to naturalise a section of concrete channel between Fadden Pines District Park and Ashley Drive before it enters Tuggeranong Creek. Preliminary flow and velocity estimates indicate that the naturalised channel could be converted to a vegetated swale to provide some treatment of stormwater prior to entering Tuggeranong Creek and subsequently Isabella Pond. It is proposed that the swale would occupy the area currently occupied by the concrete channel to avoid the requirement to re-grade banks and remove trees, however, it is noted that the capacity of the channel would be reduced slightly.

The width and depth of the swale varies along the channel. The channel becomes wider and deeper as the catchment increases downstream. It is also noted that the upstream portion of the channel is quite steep (1.9% longitudinal slope). Further assessment of velocities in this portion should be undertaken to ensure vegetation within the channel can withstand floods / heavy flows.

It is expected that the creek naturalisation will improve ecosystem value through increased diversity in habitat.

### 7.1.32 LT021A-Bioretention (catchment area 35.3 ha)

A large bioretention system is proposed at Site 21A, to assist in treating a catchment area of approximately 35.3 hectares, which is entirely urban. The total treatment area for the bioretention system shown in this plan is approximately 1,454 $m^2$, which is approximately 0.41% of the catchment area. The bioretention system has been sized to meet best practice standards.

The treatment system has been positioned to minimise removal of existing trees (no mature trees require removal) and leave a large area of open space for activities such as dog-walking and kick-around sports. The larger landscaping area identified around the proposal is the ideal size for amenity improvement, and would involve understorey planting beneath existing trees (note the costed amount is for a smaller area – 30% of the bioretention area). The construction of the bioretention system is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.33 LT021B-Bioretention (catchment area 28.3 ha)

A bioretention system is proposed at Site 21B, to assist in treating a catchment area of approximately 28.3 hectares, which is entirely urban. The total treatment area for the bioretention system shown in this plan is approximately 690 $m^2$, which is approximately 0.24% of the catchment area. The bioretention system has been sized to meet best practice standards.

The treatment system has been positioned to minimise removal of existing trees (no mature trees require removal) and leave a large area of open space for activities such as dog-walking and kick-around sports. The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees (note the costed amount is for a smaller area – 30% of the bioretention area). The construction of the bioretention system is expected to improve ecosystem value through increased diversity in habitat.

### 7.1.34 LT022-Bioretention and storage pond for water reuse (catchment area 23.36 ha)

Chisholm Neighbourhood Oval had several surrounding catchments however the most viable was a 23.4 hectare catchment (all urban) to the south where invert levels and distances were most favourable. A diversion would be from contour 617 m AHD and run 190 m to a bioretention system and treatment and storage pond.

The treated flows from the bioretention system would fill storage pond for irrigation use onsite. The location of the header tank is assumed to be on the opposite side of the oval. A pump and rising main would feed the header tank and overflows would be piped to the stormwater main north of the treatment area.

The landscaped area shown in the image is the ideal shape and size (note the costed amount is for a smaller area – 30% of the treatment area). Together with the pond and bioretention system it is expected the ecosystem and biological diversity will improve, as too will the amenity value of the site with varied features and recreational opportunities from the seating, paths and nature appreciation.

A concrete access track will run between the bioretention system and pond, with an additional rock path to connect to the paved footpath to the north.

### 7.1.35 LT023-Bioretention (catchment area 135.7 ha - 87% of flow treated)

There is a large catchment that runs along Isabella Drive before discharging into a channel near Chisholm District Playing Fields. A diversion pit would be installed at contour 627 m AHD, with a diversion rate of 2000 L/s. This will divert a 393 ML/yr of the total catchment flow of 452 ML/yr. A tiered bioretention system will have two levels built into the landscape that bounds Isabella Drive. The location shown in the image is preferred over the land closer to the existing footpath as it is flatter, allowing an increased area for treatment. Levels permitting, the overflow pit and subsoil drainage outlet will connect back to the stormwater main on the southern side of the road, rather than under the footpath underpass west of the system – this would require more costly excavation/underboring.

It is expected the 525 mm diameter stormwater line that runs through the system at present would be buried deeper than the base of the lowest tier of the system (621.15 mAHD).

Landscaping shown in the image is the ideal size and shape for development. There is a copse of trees (presumed to be pines) that would require removal at this site, however the overall impact of the treatment system and development of surrounds is expected to be an improvement to existing ecosystem and amenity. Two 250 kL storage tanks will store and supply water to the adjacent playing fields.

### 7.1.36 LT023W-Wetland (catchment area 135.7 ha - 17% of flow treated)

There is a large catchment that runs along Isabella Drive before discharging into a channel near Chisholm District Playing Fields. It is proposed that a diversion pit be installed at contour 625.5 m AHD. This will divert a 135.7 hectare catchment, of which 107.3 hectares is urban (excludes rural and bushland). As this wetland is undersized, a diversion rate of 75 L/s is required. This will divert 26 ML/yr of the catchment's total flow of 452 ML/yr.

Levels permitting, the overflow pit from the tanks and outlet pipe from the wetland will connect back to the stormwater main on the southern side of the road, rather than under the footpath underpass west of the system – this would require more costly excavation/underboring. It is expected the 525 mm diameter stormwater line that runs through the system at present would be buried deeper than the base of the wetland (621.2 m AHD).

Two 500 kL tanks would be buried underground, beneath the wetland, and would have low flows drain into them for storage and supply to the adjacent Chisholm District Playing Fields via a pump and rising main.

### 7.1.37 LT024-Wetlands (catchment area 13.86 ha)

A wetland is proposed for the open space off Hawkesworth Place. A small catchment of 13.86 hectares (9.4 hectares is urban) currently drains along this street and would be diverted to a wetland for treatment.

The sediment basin is large in relation to the wetland, this is because the site is constrained by a water line running through the centre of it. The larger sediment basin will improve the treatment effectiveness of the system. The landscaped area shown in the image is the ideal shape and size and with the wetland area and associated footpath and seating is expected to improve biological diversity and amenity of the area – however this design would require 3 mature trees be removed. Note that the costed amount is for a smaller landscaped area – 30% of the wetland area.

Access to the site would be along existing paths the meet Hawkesworth Place and Mules Place to the north, an additional access track into the sediment basin is provided.

### 7.1.38 LT025A-Bioretention (catchment area 1182 ha [368 ha urban] - 53% of flow treated)

Tuggeranong Homestead presents a great opportunity to treat a large volume of water due to its open space, especially in the north of the site. At this location a large bioretention system is proposed to treated a diverted portion of water that flows along the adjacent channel. The upstream catchment is 1182 hectares, of which 367 hectares is urban (excludes rural and bushland). Due to the low grade of this area a long diversion pipe is required to convey flows from the channel to the open space to the north. A diversion at contour 603 m AHD in the channel would divert 1080 ML/yr of the total 2050 ML/yr flowing from the catchment to the site for treatment.

The tiered system proposed is preferred over a single layered bioretention system, as it will sit within the landscape better, and also reduces excavation costs. The landscaped area shown is the ideal shape and size for vegetation, however minimal landscaping may be preferred to maintain the existing grassy landscape (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area). Paths and a concrete access track can be added to the design if the community would like increased access to this area of the Homestead.

The cost of the diversion is relatively large due to the length and size of pipes required to convey significant flows to this site.

### 7.1.39 LT025B-Wetland (catchment area 8.7 ha)

A second option for Tuggeranong Homestead involves the diversion of a small nearby residential catchment of 8.70 hectares (all urban).

A diversion pit at contour 604 m AHD on the western side of Ashley Drive requires approximately 30 m of underboring across the road, out of a total 150 m diversion to reach the sediment basin. A wetland would snake its way down the mild slope of the northern half of the Homestead property. An outlet pipe would discharge treated flows to the existing stormwater channel.

The landscaped area shown in the image is the ideal size, however this may be reduced or not included if it is preferred to maintain the existing open, grassy space. Seats are included in the design, however paths and an access track were not included – these can be added once the Homestead has been consulted about the level of development of any of the land.

It is expected the wetland will help improve the biological diversity and amenity of the site, requiring no tree removals.

### 7.1.40 LT025C-Restoration of creek flow (baseflow from Tuggeranong Creek) - to be considered with LT025A or LT025B

A third option for Tuggeranong Homestead, which can be considered in addition to either of the other options, is the rehabilitation of the original Tuggeranong creekline that runs through the Homestead. This idea has previously been suggested and investigated by Ian Lawrence and SMEC Engineering.

A variation on previous suggestions this design is a low cost, simple diversion from the stormwater channel using a small solar pump (3 L/s) and an 80 m rising main to reach the original creekline. Rather than a series of ponds or a wetland it is proposed that the creek be rehabilitated through the constant flow of the baseflow from the channel, calculated to be approximately 1.4 L/s. It was assumed there would be moderate treatment of the flow in the creekbed that would act like a swale or wetland due to the low longitudinal slope (1.6%), with a removal rate of 50% for TSS, TP and TN. The small depression at contour 601 m AHD could also act to retard a portion of the flow.

This will be an excellent community engagement opportunity as there are several aspects of the scheme that would be ideal for community involvement – it has been established that some existing vegetation around the creekline requires removal prior to restoration of the creek (SMEC). Along with ongoing maintenance and replanting, these activities and related planning would be ideal for community engagement.

### 7.1.41 LT027-Pond (urban catchment area 65.9 ha -59% of flow treated)

A pond is proposed at Site 27, to assist in treating a catchment area of approximately 133.3 hectares, of which 62.4 hectares is urban. The total treatment area for the pond as shown in this plan is approximately 8,122 $m^2$, which is approximately 1.3% of the urban catchment area. The pond has been sized to meet best practice standards. It is noted that only low flows will be diverted to the pond for treatment (i.e approximately 59% of flow).

The pond will add to the diversity of the recreational space (e.g. nature appreciation). However, the majority of the oval is currently used for recreation (e.g. kick around sports) and this function will be lost. The construction of the pond system is expected to improve ecosystem value through increased diversity in habitat.

The treatment system has been positioned to minimise removal of existing trees (no mature trees require removal). The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees.

### 7.1.42 LT028-Bioretention and wetland located on former landfill (catchment area 86.0 ha)

A wetland and bioretention system are proposed at Site 28, to assist in treating a catchment area of approximately 86 hectares, which is entirely urban. The total treatment area for the wetland is 5,660 $m^2$ and 910 $m^2$ for the bioretention system, as shown in this plan, which is approximately 0.76% of the catchment area. The wetland and bioretention systems have been sized to meet best practice standards. It is noted that a pond has recently been constructed to the north-east of the site as part of a new residential aged care development and this should be considered during further assessments.

The treatment train is partially located on a former landfill site which can be seen by the use of the site for spoil disposal as evidenced by the mounds in the centre of the site. This has been the major cost driving factor, in conjunction with the excavation required as the site is slightly elevated in comparison to its surrounds.

The treatment system has been positioned to minimise removal of existing trees (four mature trees require removal). The larger landscaping area identified around the proposal is the ideal area for amenity improvement, and would involve understorey planting beneath existing trees. The construction of the treatment system is expected to improve ecosystem value through increased diversity in habitat. The treatment system will also add to diversity and interest of open space with improved landscaping with opportunities for viewing area, seating and art.

### 7.1.43 LT028W-Wetland on former landfill (catchment 86ha - 79% of flow treated)

A wetland is proposed at Site 28W, to assist in treating a catchment area of approximately 86 hectares, which is entirely urban. The total macrophyte treatment area for the wetland is 8,817 $m^2$, as shown in this plan, which is approximately 1.02% of the catchment area. The wetland system has been sized to meet best practice standards. It is noted that only low flows will be diverted to the wetland system (i.e 79% of flows). It is also noted that a pond has recently been constructed to the north-east of the site as part of a new residential aged care development and this should be considered during further assessments.

The wetland is partially located on a former landfill site which can be seen by the use of the site for spoil disposal as evidenced by the mounds in the centre of the site. This has been the major cost driving factor, in conjunction with the excavation required as the site is slightly elevated in comparison to its surrounds.

The treatment system has been positioned to minimise removal of existing trees (four mature trees require removal). The construction of the treatment system is expected to improve ecosystem value through increased diversity in habitat. The treatment system will also add to diversity and interest of open space with improved landscaping with opportunities for viewing area, seating and local art. The larger landscaping area identified around the proposal is the ideal area for amenity and habitat diversity improvements, and would involve understorey planting beneath existing trees.

### 7.1.44 LT029-Bioretention (catchment area 113.1 ha)

Two bioretention systems are proposed at Site 29, to assist in treating a catchment area of approximately 113.1 hectares, of which 84.7 hectares is urban. The total treatment area for the bioretention systems shown in this plan is approximately 3,000 $m^2$, which is approximately 0.35% of the urban catchment area. The bioretention systems have been sized to meet best practice standards.

The treatment system has been positioned to minimise removal of existing trees (two mature trees require removal) and leave a large area of open space for activities such as dog-walking and kick-around sports. The construction of the bioretention systems is expected to improve ecosystem value through increased diversity in habitat. The larger landscaping area identified around the proposal is the ideal area to provide additional amenity and habitat diversity improvements, and would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area).

### 7.1.45 LT029W-Wetland (catchment area 113.1 ha - 28% of flow treated)

A wetland system is proposed at Site 29W, to assist in treating a catchment area of approximately 113.1 hectares, of which 84.69 hectares is urban. The total macrophyte treatment area for the wetland, as shown in this plan is approximately 2,580 $m^2$, which is approximately 0.30% of the urban catchment area. The wetland system has been sized to meet best practice standards. It is noted that only low flows will be diverted to the wetland system (i.e 28% of flows).

The treatment system has been positioned to minimise removal of existing trees (two mature trees require removal) and leave a large area of open space for activities such as dog-walking and kick-around sports. The construction of the wetland is expected to improve ecosystem value through increased diversity in habitat. The larger landscaping area identified around the proposal is the ideal area to provide additional amenity and habitat diversity improvements, and would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area).

### 7.1.46 LT030-Bioretention and reuse (existing tanks) (catchment area 285.6 ha - 62% of flow treated)

At the drainage corridor that runs parallel to Drakeford Drive there is an opportunity to divert flows to a bioretention system between the two Kambah District Playing Fields, next to Kett Street. The upstream catchment is 285.6 hectares, of which 117 hectares is urban (excludes rural and bushland). The proposed bioretention system for this site is undersized for this catchment and hence a diversion rate of 1000 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 335 ML/yr of the total 540 ML/yr flowing from the catchment for treatment.

The bioretention system has been placed at the boundary of the urban open space zone and the transport zone, with the intention to be ‘offline’ from the assumed overland flow path as much as possible, to avoid scouring during times of high stormwater flows. It is likely a telecoms line (Optus) would need realignment around the bioretention system at this location.

Treated stormwater would be pumped to the adjacent storage tanks at Kambah District Playing Fields (east) for reuse onsite. High flows would flow back into the adjacent stormwater pipe.

### 7.1.47 LT030P-Pond and reuse (existing tanks) (catchment area 285.6 ha - 29% of flow treated)

At the drainage corridor that runs parallel to Drakeford Drive there is an opportunity to divert flows to a pond between the two Kambah District Playing Fields, next to Kett Street. The upstream catchment is 285.6 hectares, of which 117 hectares is urban (excludes rural and bushland). A proposed pond for this site is undersized for this catchment and hence a diversion rate of 200 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 156 ML/yr of the total 540 ML/yr flowing from the catchment to the pond for treatment.

The pond has been placed at the boundary of the urban open space zone and the transport zone, with the intention to be ‘offline’ from the assumed overland flow path as much as possible, to avoid scouring during times of high stormwater flows. It is likely a telecoms line (Optus) would need realignment around the bioretention system at this location.

Treated stormwater would be pumped to the adjacent storage tanks at Kambah District Playing Fields (east) for reuse onsite. High flows would flow back into the adjacent stormwater pipe.

### 7.1.48 LT031-Bioretention (catchment area 85.83 ha)

A set of bioretention systems are proposed at the intersection of Athllon Drive and Drakeford Drive. A 85.8 hectare catchment (all urban) would be diverted at the north-east corner of the roundabout on Fincham Crescent and Wheeler Crescent. The diversion would run along Wheeler Crescent, following an existing footpath and then through to the open space within the open space. A diversion pit would split the diverted flow into two separate bioretention cells, totalling 1,600 sq.m, for treatment and then discharge to the stormwater channel that runs through the reserve

The larger landscaping area identified around the proposal is the ideal area, and would involve understorey planting beneath existing trees (note the costed amount for landscaping is for a smaller area – 30% of the total treatment area). To make space for this system 9 juvenile and 5 small shrubs would require removal. Care was taken to avoid any mature trees as this site has Aboriginal scarred trees registered on the ACT Heritage Register.

Cell B would have a boardwalk through the centre of the system and an additional pathway would connect existing paths via a short route between the bioretention systems and trees, improving amenity of the site.

### 7.1.49 LT031W-Wetland (catchment area 85.83 ha - 26% of flow treated)

A 85.8 hectare catchment (all urban) drains into the stormwater channel immediately upstream from Lake Tuggeranong. It would be diverted at the north-east corner of the roundabout on Fincham Crescent and Wheeler Crescent to flow into a wetland for treatment. The wetland is undersized for this catchment and hence a diversion rate of 80 L/s is required to ensure treatment is optimised to meet best practice standards. This will divert 71 ML/yr of the total 270 ML/yr flowing from the catchment. The diversion would run along Wheeler Crescent, following an existing footpath and then through the open space to the proposed treatment site.

Note the larger landscaping area identified around the proposal is the ideal area, the costed amount is for a smaller area – 30% of the total wetland area. To make space for this system 6 mature trees and 12 juvenile trees/small shrubs would require removal. Care was taken to avoid any mature, native trees as this site has Aboriginal scarred trees registered on the ACT Heritage Register. Further investigation is required to identify these scarred trees and ensure their heritage status is not affected by development of this site.

### 7.1.50 LT032-Conversion of concrete channel (Tuggeranong Creek) to a swale

A concept plan has been developed for Site 32 (Tuggeranong Creek Cluster) to naturalise a section of concrete channel between Tharwa Drive and Isabella Pond. Preliminary flow and velocity estimates indicate that the naturalised channel could be converted to a vegetated swale to provide some treatment of stormwater prior to entering Isabella Pond. It is proposed that the swale would occupy the area currently occupied by the concrete channel to avoid the requirement to re-grade banks and remove trees, however, it is noted that the capacity of the channel would be reduced slightly. As such further assessment of flood flows is required. It is noted that the channel width is constrained in parts by services and a regional cycle path.

The width of the swale varies along the channel. The channel becomes wider as the catchment increases downstream.

It is expected that the creek naturalisation will improve ecosystem value through increased diversity in habitat.

# 8 Discussion

## 8.1 Developing catchment management strategies in the ACT

Effective water quality management requires a combination of activities running as part of a coordinated strategy. Infrastructure solutions are a key component to physically and biologically manage sediment, nutrients and toxicants. However, without complementary efforts in planning controls, source controls, asset maintenance, agency capacity and community education, infrastructure investment can become less effective. In some cases, non-infrastructure solutions can deliver longer-term and better outcomes.

The approach to catchment management to improve water quality varies in response to the type of catchment involved. Over rural catchments, the water quality issues (sediment, nutrients) are strongly linked to land management activities and soil type, but also may be affected by diversion of flows for irrigation. In peri-urban areas, land management activities and soil type are still important along with greater harvesting of water through farm dams. In some areas, septic tank systems can impact on waterway water quality. In urbanised catchments, water quality issues are strongly linked to increased imperviousness (increased stormwater runoff) and urbanised land use (such as roads), and may be impacted by leaking sewers or sewer surcharge, industrial trade waste making its way to stormwater systems, and garden fertilizers.

### 8.1.1 Urban catchments

The Tuggeranong catchment has a large portion of residential areas including the suburbs of Kambah, Wanniassa, Greenway, Oxley, Monash, Gowrie, Fadden, Macarthur, Gilmore, Chisolm, Richardson, Isabella Plains, Calwell and Theodore. There is a rural catchment upstream of Richardson, but the majority of the catchment is urbanised and is dominated by residential land use (see Figure 2 and Figure 3). There are a range of financial, technical, institutional and management challenges that need to be considered in meeting stormwater quality objectives.

#### *8.1.1.1 Non- structural controls*

While this project focuses on the infrastructure controls available to manage water quality, there are a range of non-structural stormwater management elements that can be undertaken to complement capital projects including:

- Town planning controls (e.g. statutory planning instruments requiring stormwater quality to be addressed in new development through Water Sensitive Urban Design [WSUD] principles).
- Strategic planning and institutional controls (e.g. strategic, city-wide urban stormwater quality management plans and secure funding mechanisms to support the implementation of these plans).
- Pollution prevention procedures such as:
    - practices undertaken by stormwater management authorities involving maintenance (e.g. maintenance of structural BMPs and the stormwater drainage network); and
    - elements of environmental management systems (e.g. procedures on material storage and staff training on stormwater management).
- Education and participation programs (e.g. targeted media campaigns, training programs and stormwater drain stencilling programs).
- Regulatory controls (e.g. enforcement of local laws to improve erosion and sediment control on building sites and the use of regulatory instruments such as environmental licences to help manage premises likely to contaminate stormwater).

The ACT Water Strategy 2014-44 ("Striking the Balance", August 2014) identifies amongst its key strategies to "achieve integrated catchment management across the ACT and region". Therefore addressing this issue is on the high-level agenda. A catchment master plan would sit alongside the WSUD Code and guide its application in specific locations. It would encourage consideration of stormwater management earlier in the land use planning and estate design process. It would also guide the planning and design of retrofit projects in older suburban areas. It should be linked to:

- receiving water quality objectives,
- other objectives such as flood detention, water reuse, recreation and habitat, and
- land use planning, including precinct plans for greenfields and urban consolidation projects.
- design, construction and establishment reforms including:
    - Update design standards, asset review, and acceptance processes.
    - Adopt appropriate staging techniques for stormwater treatment systems in new estates.
    - Acknowledge establishment as a critical phase and allocate funding accordingly.

## 8.2 Considerations for stormwater treatment infrastructure implementation

### 8.2.1 Operation and maintenance

Limitations at the operations and maintenance stage currently represent a fundamental challenge for improving the performance of stormwater treatment in the ACT. The maintenance budget for stormwater treatment is significantly under-resourced. An increasing number of stormwater treatment systems have not been matched by increased maintenance funding and therefore this budget is becoming further and further stretched. Maintenance practices are therefore confined to a basic minimum level of service. Larger tasks are undertaken on a reactionary basis when significant issues occur, and there is little or no capacity for monitoring, review or planning. Tables 13 and 14 provide a guide to the best practice operation and maintenance of wetland and bioretention systems.

**Table 13. Example schedule of maintenance requirements for a bioretention system**

| Element | Maintenance Activity | Recommended frequency | Hints and Tips |
|---|---|---|---|
| Inlet area | Removal of litter, debris and sediment | 4-8 times per year | Bioretention systems are often designed with a sediment forebay at the inlet to make this area easier to clean. If the inlet is cleaned regularly, it can reduce the amount of litter, debris and sediment accumulating on the filter surface |
| | Repair any structural damage | As required | |
| Filter surface | Removal of litter and debris | 4-8 times per year | |
| | Check for unusual ponding | 4-8 times per year | Check after rain events that water has all drained away within a few hours. If not, sediment removal may be required as described below. |
| | Sediment removal | Once every ~5 years | Sediment should be removed when flows are restricted by a “blinding layer” or when there is approximately 50 mm of build-up on the filter surface. Scrape away accumulated sediment and restore filter to design levels. Note that vegetation replacement may be required at the same time. |
| | Repairing any scour or erosion | As required | May be required after a large storm event |
| Vegetation | Pruning, weeding, replanting, mulching | 4-8 times per year | |
| Outlet | Removal of litter, debris and sediment | 4-8 times per year | |
| | Repair any structural damage | As required | |
| Under-drainage pipes | Flushing | ~10 years or as required | Most under-drainage pipes rarely need flushing |

**Table 14. Example schedule of maintenance requirements for a wetland system**

| Element | Maintenance Activity | Recommended frequency | Hints and Tips |
|---|---|---|---|
| Inlet and outlet structures | Clear blockages, remove sediment and debris | 3 monthly | Ensure water can move freely into the wetland. Note that the outlet should include a specially designed flow-restricted outlet. |
| | Repair any structural damage | As required | |
| Inlet zone (e.g. sediment pond/basin) | Monitor sediment accumulation | Annually | Sediment removal is typically recommended when the basin is 2/3 full |
| | Sediment removal | Typically designed for cleanout once every ~5 years | Note that in most cases, the inlet zone is designed so that it can be drained for maintenance without draining the whole wetland.<br>Note that a GPT installed upstream of the inlet zone can extend the time between cleanouts. |
| Vegetation within macrophyte zone | Harvesting, weeding, and replanting | 3 monthly | Note that plant establishment (including initial plant establishment and any replanting during the wetland's life) requires careful water level control to ensure that newly establishing plants are not drowned in deep water. |
| High flow bypass | Repair scour and erosion | Check each 3 months and repair as required | |
| | Maintain conveyance capacity | Check each 3 months and maintain as required | remove any blockage/debris and prune excessive vegetation growth |

### 8.2.2 Design, Construction and Establishment

The key risks for the implementation phase of the Basin Priority Project are concentrated in the design, construction, establishment and asset handover processes, where there are limitations in terms of industry and government capacity, as well as poor systems and processes and significant gaps in guidelines and standards. To address this, the following considerations should be integrated into the design process:

- Concepts developed need to be considered in-line with catchment-scale planning and analysis
- Concepts that are proposed downstream of catchments in transition (new developments) need to address issues surrounding high sediment loads and construction activities
- Design of stormwater treatment assets should be undertaken using latest design standards and specifications
- Growing seasons and establishment periods for vegetated stormwater treatment systems should be incorporated into planning and implementation stage requirements to help ensure success
- Operations and maintenance limitations need to be identified and considered in designs wherever possible.

Key pollutants of concern in the priority catchments include TSS and TP. TN also contributes to eutrophication in waterways; however TP is typically the limiting nutrient which triggers blue-green algal blooms in the region. Gross pollutants (i.e. litter) are a particular issue downstream of commercial and industrial areas. They tend to be significantly less prevalent in residential areas. The urban areas of the priority catchments are dominated by residential areas; however there are also significant commercial areas, particularly Town Centres. These areas should be the focus for management of gross pollutants. Other contaminants of concern in all urbanised catchments include common toxicants such as heavy metals and hydrocarbons. A strategy which addresses gross pollutants (focusing on commercial areas), fine suspended and dissolved pollutants would be appropriate for the priority catchments. Treatment trains for reducing pollutant loads should be designed to address pollutants in the following order from upstream to downstream:

- Gross pollutants
- Coarse suspended solids
- Fine suspended solids
- Dissolved pollutants

Actions to reduce pollutant loads could include:

- Gross pollutant traps immediately downstream of commercial areas
- Stormwater treatment systems (e.g. bioretention systems and wetlands) at a range of scales from individual lots to large systems in public open space
- Rainwater and stormwater harvesting can also reduce pollutant loads, particularly if it is widespread and linked with significant water demands
- Riparian revegetation and stock exclusion fencing in the rural areas to limit erosion and sediment liberation.

There are some key gaps in the strategic framework for stormwater management in the ACT. These gaps include the following:

- There are a wide range of different treatment trains in place and stormwater quality outcomes are likely to differ widely between catchments. However, we have not seen any analysis of stormwater quality and treatment outcomes on a catchment scale.

- The “development” and “regional” targets set in the WSUD Code have been set to manage stormwater quality from urban areas such that it meets the same standards as a well-managed rural catchment. While this seems a reasonable goal, it does not consider the different values of different receiving waters (e.g. lakes, creeks and rivers) which may be sensitive to different stormwater quality issues. The Water Use and Catchment General Code only classifies catchments as one of three types (conservation, water supply, drainage and open space) which doesn’t add much detail. The ACT has a complex set of varied water management objectives to consider, with receiving waters including urban lakes (e.g. Lake Burley Griffin, Lake Ginninderra and Lake Tuggeranong), urban ( e.g. Sullivans Creek and Yarralumla Creek), natural creeks (e.g. Ginninderra and Gungaderra Creek), local rivers (e.g. Molonglo River) and regional rivers (e.g. Murrumbidgee River).

- While stormwater treatment targets are codified for new development, the objectives for retrofits are less clear. Where retrofit projects have been undertaken, each project has had its own objectives and the stormwater treatment objective is not always clear.

- In older catchments such as Tuggeranong Creek, there is a need to re-think the treatment train The approach in the 1970s was to place large GPTs towards the downstream end of the catchment, such as the case with the online GPTs upstream of Isabella and Upper Strangers Ponds. However now that a higher standard of treatment is desired, new stormwater treatment systems targeting finer pollutants are being installed within the catchments.

- In some newer suburbs, stormwater is treated multiple times as it moves downstream through the system, and there is redundancy in the treatment train.

# 9 References


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# Appendix A - Design development assumptions

# Concept design assumptions

In developing the concept designs for each site, a range of assumptions were used, as outlined in Table 15. All the concept designs were developed to a functional feasibility stage. This level of detail will ensure the concepts at each site work, however, it does not include detailed site surveys or investigations. The concept designs relied on GIS information (e.g. GIS layers for contamination, heritage, trees and invert levels), which will need to be verified during the detailed design stage. This may alter the treatment systems proposed and/or the costs associated with the detailed design and construction. To allow for this, the costings include a 40% contingency as agreed with the ACT Government.

**Table 15. Concept design assumptions**

| Assumption | Comment |
|---|---|
| MUSIC modelling | MUSIC modelling was undertaken using parameter settings agreed with the ACT Government. These parameter settings were used by all consultants for consistency.<br>Treatment area to catchment ratios were developed in MUSIC to allow for initial approximate sizing of treatment systems. MUSIC was then used to refine concept schemes for each treatment location to determine treatment-specific pollutant load reductions.<br>Where the site was constrained by size (i.e. the maximum size of treatment system was not capable of treating the upstream catchment to best practice standards), MUSIC was used to determine the percentage of catchment flows which could be diverted to the treatment system for treatment to best practice standards. |
| Cut and fill | Rough cut and fill calculations for each site were taken into consideration at the initial design level. Where invert levels of an inlet pipe resulted in excavation greater than 2m depth below surface level, thus requiring a large amount of excavation, it was not deemed feasible and a diversion was incorporated.<br>Once finalised, more detailed cut and fill calculations were performed to include outer, built-up embankments (where relevant) at a batter slope of 1 in 5. When a design was cut into the natural surface, the slope varied from 1 in 4 for a bioretention system, to 1 in 6 for a wetland, pond or swale. A batter slope of 1 in 5 was used where a wetland, pond or swale site was constrained and 1 in 3 for a constrained bioretention site. |
| Diversions | Diversion length calculations included the initial invert level, the new invert level based on the diversion pipe diameter, and the length and slope of the diversion pipe. A starting point of a 1% gradient slope was preferred, down to a minimum of 0.5% gradient where constrained by distance. This calculation resulted in the inlet level for the relevant treatment system. |
| Inverts | Where invert level data was not available for a specific pit upstream of the treatment system, surrounding known invert level data was used to provide an average. In most cases where a level was provided it was accurate to +/- 0.5 m. There was a limited dataset available that had invert levels accurate to +/- 0.0005 m.<br>There were some sections in the catchment where no data was available for any part of a suburb (or more). In this instance, judgement was used to assume a conservative depth from natural surface to the invert level, based on slope and known existing pipe diameters. Where this took place it has been noted on the concept design. |
| Services | Services were identified from GIS layers provided by ACT Government and included stormwater, mains water, sewage, electricity and gas. Communications (Telstra and Optus) were obtained by undertaking a Dial Before you Dig search for each catchment.<br>It is noted iinet also has communications services in the ACT. However, they were not considered as DBYD searches were required to be less than 0.1 sq.km to receive plans from the service provider. It was assumed these services could be crossed when designing diversion and outlet pipe locations, with a cost of crossing factored into the capital costs. It was also assumed a pit could be modified or added to a pipe where services are adjacent to the pipe/pit.<br>A buffer of 3m was used when creating boundaries of treatment areas.<br>For bioretention systems it was assumed that stormwater pipes could remain in place and be embedded within the system with filter media placed around the pipe. A realignment of a service was included in some designs where it could not be avoided. This constraint was factored in as an increased cost compared with a service crossing, at $200/m of the realignment. |
| Open space | In an area of open space that could conceivably be used for recreation (e.g. informal playing and kickabout) a proposed treatment system was situated and sized to minimise impact on the site. As |

| | |
|---|---|
| | wetlands and ponds were larger than bioretention systems (for the same treatment effectiveness) bioretention systems were chosen over ponds and wetlands for smaller sites.<br>Playgrounds and playing fields were generally avoided and designed around, and footpaths and cycleways were realigned around the treatment area or a path recreated across the treatment area (eg. boardwalk through a bioretention system or wetland). |
| Heritage | Presence of heritage was determined prior to concept design. Where possible, community consultation was undertaken with stakeholders at particular heritage listed sites (eg. Tuggeranong Homestead) to discuss possible designs and gauge interest, support and feedback on preferred systems. This was subsequently incorporated into the concept design.<br>A conservative approach was taken to avoid any listed features (eg. Scarred trees, buildings), however the land around a feature may be incorporated in designs. It was assumed further clarification of heritage restrictions would be determined at the detailed design stage. |
| Spoil | Each concept design incorporated any cut as fill elsewhere within the treatment area in the form of a builtup embankment where possible. Excess spoil excavated and not required in the design was relocated onsite as a mound where space permitted or disposed of offsite. Relocation onsite as a mound was preferred as this reduces costs. |
| Costing | Each element of the design was incorporated in the costing schedule. Various sizes and associated costs were provided for GPTs, pipes, tanks and paths.<br>Landscaping was factored into each design's costs, to a maximum area of 30% of the treatment area (e.g., wetland water level and surrounding embankments). *Note* – for purposes of illustration, a larger landscaped area is shown in the images of the concept designs – this is the ideal landscaped area for amenity improvement. |
| Rates | Unit rates were developed by Alluvium, ACT Government and other consultants for the construction of the treatment systems (e.g. pipes, filter media, excavation). The unit rates were based on previous projects undertaken in Canberra and NSW, and the Australia Construction Handbook (Rawlinsons, 2015). The same rates were adopted by all consultants across all catchments to ensure consistency. |
| Flooding | All WQ asset earthworks have been designed to not reduce floodplain storage and capacity, thus no detailed flood modelling was required. Channel naturalisation and rehabilitation has been based on the premise of maintaining the current channel capacity. This has been modelled through Manning's calculations. |
| Trees | Trees were designed around or avoided in the majority of sites where possible. Where necessary, trees were removed when they were small in number in an open area, thereby maximising available space for treatment. The size and type of tree (native or non-native) was considered in other instances. Non-native trees and vegetation was deemed acceptable for removal as replanting and landscaping was included as a part of the design. Diversions also sometimes resulted in the removal of trees, depending on the length and location of diversion. Where an existing footpath was present it was preferred to remove and repave the footpath rather than remove trees from a heavily vegetated area. |
| Access | Access was required to each site for both construction and ongoing maintenance. Where possible existing concrete paths were assumed as accessible and additional 3 m concrete paths were included to connect roads to these paths. Where no paths existed the 3 m concrete access path led from the road to the treatment system. For ponds and sediment basins, the access track went into these basins for maintenance purposes. |
| Reuse | Water consumption data related to irrigation was not available at the majority of sites and thus an assumed rate of 5 ML/ha/yr (figure provided by the ACT Government) was used to calculate an annual irrigation demand. The rate was multiplied by the irrigated area, calculated by measuring the area on aerial imagery that highlights irrigated land at parks and playing fields. This calculation provided an estimated annual irrigation demand that was input to MUSIC modelling to determine the volume and percentage of reuse demand met by each specific treatment and storage model.<br>Storage capacity of ponds and tanks (where they did not already exist) was sized according to a reuse-storage volume curve produced for each site to determine the optimal storage size (presented with each concept design where relevant). In some cases storage ponds were oversized for reuse purposes as they improved the treatment effectiveness of the system. |
| Contamination | The EPA holds records of contamination at several sites shortlisted for concept designs. This was factored into overall feasibility as a design cost, with the use of a higher rate of disposal cost of excavated spoil from the site. Disposal of excess clean spoil was \$50/m$^3$, while an extra of \$800/tonne was included where disposal was for contaminated spoil.<br>Where a site was noted for potential contamination it was assumed all excavated spoil was contaminated and was to be disposed off-site. |

# MUSIC modelling assumptions

MUSIC modelling undertaken as part of the concept design development included a range of modelling assumptions, as outlined in Table 16.

**Table 16. MUSIC modelling design assumptions**

| Treatment Type | Standardised Parameters |
|---|---|
| **Wetland** | – Inlet high flow bypasses set to 3 month ARI as starting point (can vary based on site characteristics)<br>– Inflow sediment basin = 20% of wetland volume as starting point<br>– Surface area determined by available space or limited to 2.5% of catchment area as a starting point<br>– Extended detention depth = 0.35 to 0.5 m<br>– Permanent Pool and initial volumes = 0.4 x Surface Area<br>– Outlet equivalent pipe diameter is adjusted to ensure detention time of 72 hours<br>– Exfiltration rate set to 0 mm/hr - conservative and transparent option<br>– Evaporative Loss assumed to be 125% (default). |
| **Pond** | – Inlet high flow bypasses set to 3 month ARI as starting point (can vary based on site characteristics)<br>– Extended detention depth = 0.35 to 0.5 m<br>– Site specific, but assume 2m average depth for Permanent Pool based on Quantitative Assessment Report<br>– Initial volume is full volume<br>– Exfiltration rate set to 0 mm/hr - conservative and transparent option<br>– Evaporative Loss assumed to be 100%.<br>– Outlet equivalent pipe diameter is adjusted to ensure detention time of 72 hours |
| **Sediment Basin** | – Inlet high flow bypasses set to 3 month ARI as starting point (can vary based on site characteristics)<br>– Extended detention depth = 0.35 to 0.5 m<br>– Assume 1m average depth for Permanent Pool<br>– Initial volume is full volume<br>– Exfiltration rate set to 0 mm/hr - conservative and transparent option<br>– Evaporative Loss assumed to be 75%.<br>– Outlet equivalent pipe diameter is adjusted to ensure detention time of 12 hours |
| **Free Draining Bioretention System (better TP removal)** | – Extended Detention – 0.1 to 0.5 m dependent on site characteristics<br>– Surface Area – Varies for each site, and includes estimation of only wetted area of batters up to top of extended detention - not whole batter slope area<br>– Filter Area – Area of filter media only (no batters)<br>– Unlined Filter Media Perimeter – If the system is lined (assume yes if you don't know) set to the minimum = 0.01 m<br>– Saturated Hydraulic Conductivity – Set to 100 mm/h<br>– Filter Depth – min 600 mm. Shallower than this means less water storage for plants and they are more likely to die during dry periods – Very Important for Canberra (600mm rain /year). Min 400 mm at constrained sites<br>– TN Content – set to 100 mg/kg based on testing of bioretention systems within Canberra<br>– Orthophosphate content – set to 50 mg/kg based on testing of bioretention systems within Canberra<br>– Exfiltration rate set to 0 mm/hr - conservative and transparent option<br>– Underdrain present – Yes<br>– Submerged zone – No (for free draining systems) |
| **Submerged Zone Bioretention Systems (better TN removal)** | – As above except for:<br>– Filter Depth – Varies for each site, depth above saturated zone to be max 400 mm<br>– Submerged zone – Yes (for Submerged Zone systems). Varies for each site based on both TP content in filter media and depth of saturated zone.. |
| **Gross Pollutant Traps** | – Allow for a 5 year ARI high flow bypass<br>– Transfer functions set to remove gross pollutants only |
| **Stormwater harvesting** | – The ACT Water Act 2007 Schedule 1 determines that the volume of water for irrigation of public open space parkland, sportsgrounds and residential gardens is considered to be 0.5 ML/1,000 $m^2$ *per annum* |

# Electronic Data provided to ACT Government Environment and Planning Directorate

Through the project electronic files were provided to the ACT Government Environment and Planning Directorate, which include both MUSIC files of the catchment and treatment systems and GIS files of the treatment system location.  These files as outlined in Table 17.

**Table 17. MUSIC and GIS files provided to the ACT Government Environment and Planning Directorate**

| Date | File | Comment |
|---|---|---|
| 14/08/2015 | MUSIC modelling (sqz files) | MUSIC model Base case.  One file – "Tuggeranong_Base Case_1968-77_130715.sqz" |
| 25/08/2015 | MUSIC modelling (sqz files) | MUSIC model of each treatment system for review by the ACT Government |
| 14/09/2015 | GIS Files (shape file) | GIS file of the location of each shortlisted treatment system |