alluvium

FINAL REPORT:

PSP 25 and 26

Drainage Strategy

October 2012

growth areas AUTHORITY

Document history

Revision:

Revision no.	R01
Author/s	Ciara Noone Penny Clark Rob Catchlove
Checked	Jonathon McLean
Approved	Rob Catchlove

Distribution:

Revision no.	R01
Issue date	22 August 2012
Issued to	Victoria Cook (Growth Areas Authority)
Description:	Draft Report

Contact:

Name	Alluvium Consulting Pty Ltd
ABN	67 013 663 038
Contact person	Ciara Noone
Ph.	0413 192 524
Email	Ciara.Noone@alluvium.com.au
Address	21-23 Stewart St, Richmond, Victoria 3121

Ref: L:\Projects\2012\043_PSP 25 and 26\1_Deliverables\P112043 PSP 25 and 26 Drainage Strategy Final Report_v1e.docx

Acknowledgements

Victoria Cook, GAA
Stephen Miller, Melbourne Water
Pong Wee Tyger Yeo, Melbourne Water
Deborah Riley, Melbourne Water
Glenn Wilson, Yarra Valley Water
Paul Curtis, Yarra Valley Water
Eleni Roussos, The Goodman Group
Ehab Saad, GHD

Contents

Figures

Tables

1 Introduction

Alluvium Consulting Australia (Alluvium) has been engaged by the Growth Areas Authority (GAA) to prepare a Drainage Strategy to inform the two proposed precinct structure plans (PSPs) that are located in the Craigieburn and Donnybrook area; PSP 25 and PSP 26.

The PSPs will guide future urban development in the Craigieburn and Donnybrook area. The integration of water management at this stage of the planning process allows preparation for development to take into account the best opportunities for providing water services, improving the local environment and increasing amenity. The strategy outlined in this report provides a high level schematic design proposed for integrated water management in the PSPs, comprising:

- Drainage works to minimise the impacts of flooding
- Stormwater quality works to protect the environmental health of waterways
- A protected environment for the Growling Grass Frog
- Identification of fit for purpose water supply opportunities

The strategy has been prepared taking into account the GAA's requirements to meet best practice engineering standards and integrate appropriate waterway and drainage solutions with open space, biodiversity, heritage and conservation constraints and opportunities. The proposed design aims to maximise the amenity and useability of open waterways and retarding basins, and minimise the amount of land required for water related assets.

2 Background

2.1 Study area

PSP 25 and PSP 26 are located approximately 28 kilometres north of Melbourne's Central Business District, within the Merri Creek catchment. The precincts are situated predominantly within the City of Hume, with a small section in the City of Whittlesea. Most of the land has been cleared and is currently used for agricultural purposes. The PSP locations are shown in Figure 1.

PSP 25 covers a total area of 638 hectares. It is bounded by the Hume Freeway to the west, the Melbourne-Sydney rail line to the east, Donnybrook Road to the north and by the Amaroo Business Park to the south. The Merri and Kalkallo Creeks flow into the PSP area from the north and converge downstream of Donnybrook Road, before passing under the rail line (about mid-way down the PSP areas).

PSP 26 is located immediately to the south-west of PSP 25 and covers a total area of 197 hectares. The area is bounded to the north by Summerhill Road, to the west by the Melbourne-Sydney rail line, and to the east by Merri Creek.

The major waterway within the area of PSPs 25 and 26 is Merri Creek. Two of its tributaries also enter the PSP area; Kalkallo Creek and Malcolm Creek. Merri Creek is representative of the first and second order waterways in this region which are generally characterised by good stability, good in stream habitat, and good flow characteristics. Merri Creek is however classified as poor for vegetation quality and extent and poor for water quality (Melbourne Water, 2008).

Figure 1. *Locality map of PSP 25 and 26*

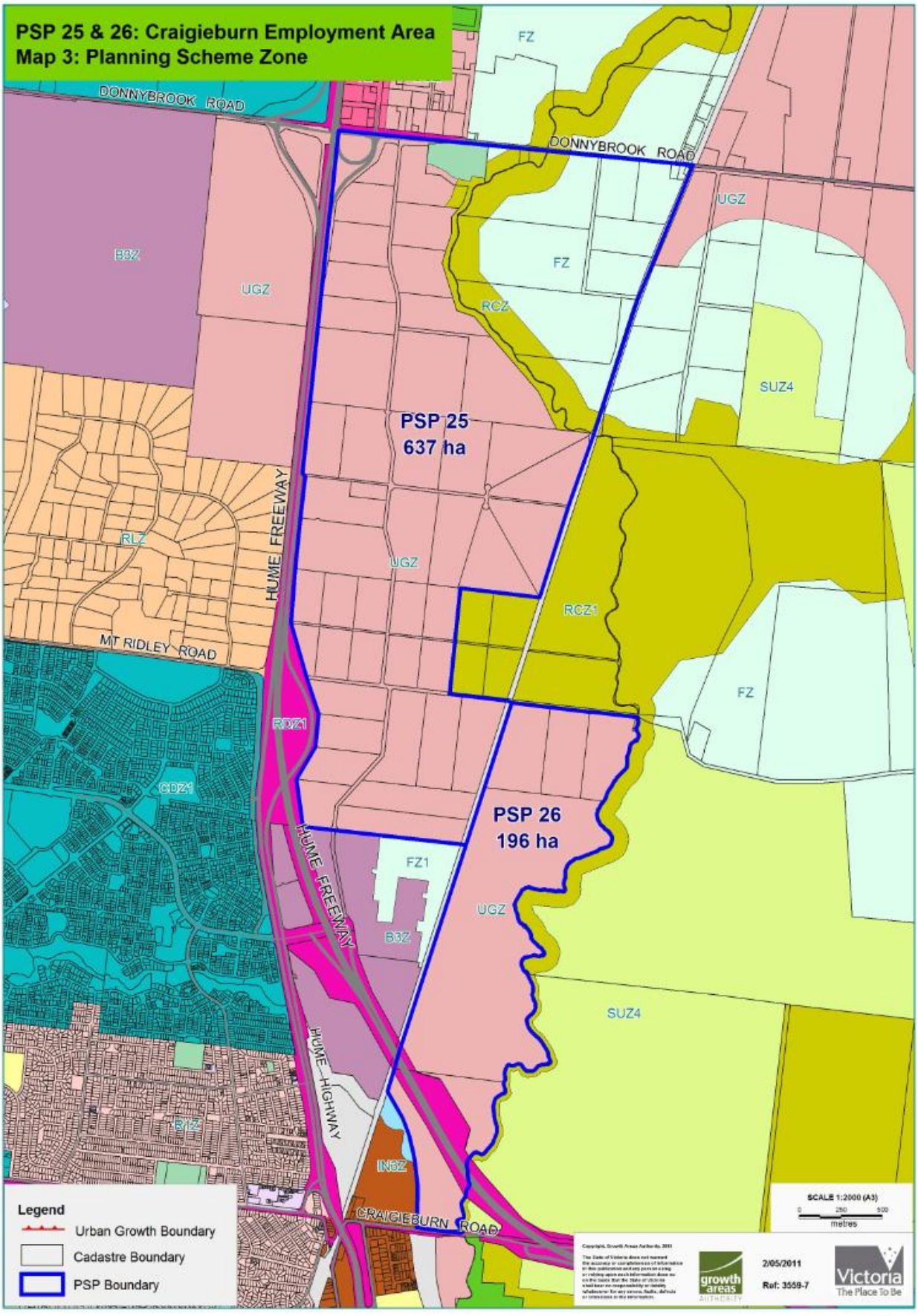

Figure 2. *PSP 25 and PSP 26 planning scheme zones (GAA, 2011)*

2.2 Proposed development

The 2011 Draft Growth Corridor Plan (GAA, 2012) nominated development for PSP 25 as 'Industrial' and for PSP 26 as 'Urban – Land Use to be determined' (Figure 2). The study area is wholly located within Melbourne's Urban Growth Boundary.

The PSP 25 Employment Precinct is approximately 417ha and the GAA have predicted that at 30 jobs per hectare, the development will generate approximately 12,500 new jobs (GAA, 2012).

2.3 A 'Water Sensitive City' approach

The traditional approach to growth area planning has been to prepare separate, isolated strategies for stormwater, water supply, river health and frog conservation. However an integrated water strategy for PSP 25 and 26 should incorporate all these elements, identifying cross over opportunities and linkages. In order to provide an urban water system that is resilient to the pressures of climate change and population growth, it is useful to adopt a strategy based on a Water Sensitive City philosophy. This approach involves consideration of how we can best manage our water resources to meet our social, economic and environmental needs. The three key attributes of a Water Sensitive City are:

- Efficiently use water from the diverse water resources available;
- Enhance and protect the health of urban waterways and wetlands; and
- Mitigate against flood risk and damage.

Implementation of this philosophy is evolving in the Victorian urban water industry, as government agencies and stakeholders are working through how the Water Sensitive City vision can be realised. The 2009 "Transition to a Water Sensitive City" Australian water industry lead a study tour that identified the following nine steps to achieve a balance between the natural and built environments:

- Personal water use: set a target that enables individuals to make a difference
- Water efficiency: set the benchmark for water efficiency
- Leadership and profile: celebrate leadership and establish a city sustainability profile
- Collaboration: team up with non-traditional partners
- City-wide strategies: think city-wide and focus on liveability
- Link water and energy: promote innovation through the water and energy industry partnerships
- Water Centre: provide a space for learning and interaction
- Healthy waterways: recognise that healthy cities rely on healthy waterways
- Water neighbourhoods: decentralised systems deliver flexibility and resilience at local scales.

Many of these steps are relevant to PSP 25 and 26.

2.4 Waterway health and stormwater management

The current best practice criteria for waterway health focuses on reducing pollutant loads (suspended solids, phosphorus, nitrogen and gross pollutants) to improve stormwater quality prior to entering waterways. However urban development also results in too much stormwater runoff entering waterways which impacts on their health. This strategy therefore considers opportunities to design an urban water system that addresses both stormwater quality and quantity impacts on the health of receiving waterways.

To incorporate these two areas involves protecting the streams from stormwater runoff by keeping as much of it as possible in the catchment. Urban developments are typically built with drainage systems that convey water into creeks and rivers as quickly as possible, whereas prior to development, rainfall would infiltrate into

the soil so that overland runoff occurs later in a rainfall event, and typically of less volume. Waterways therefore are subject to more frequent disturbances from runoff. Recent studies by Monash and Melbourne University suggest that catchments should aim to reduce the number of runoff days to less than 15 per year, (compared with traditional drainage systems which result in greater than 100 surface run off days).

Design of the stormwater system for PSP25 and 26 should attempt to mimic the natural environment and reduce the amount of runoff entering the Merri and Kalkallo Creeks. This strategy identifies opportunities to capture water in natural depressions and allow infiltration through pervious soil to reduce the runoff to the catchment. There is a direct link between high areas of imperviousness and poor waterway health, therefore pervious areas in the PSP area (and the upstream catchments) are critical to protecting the health of the creeks.

2.5 Growling Grass Frog conservation

The Growling Grass Frog (Figure 3) is listed as "Vulnerable" nationally under the *Environment Protection and Biodiversity Conservation Act* 1999. In Victoria it is listed as "Threatened" under the *Flora and Fauna Guarantee Act* 1988 and classified as "Endangered" (DSE 2011).

The Growling Grass Frog is known to occur along the banks of the Merri Creek, and the increased development in the area poses a threat to this habitat.

In response to the increased threat that urban development poses to Growling Grass Frog habitat, a Sub-regional Species Strategy for the Growling Grass Frog (The GGF Strategy, 2011) has been prepared by DSE in four growth areas within Melbourne's Urban Growth Boundary. The GGF Strategy aims to identify important populations of frogs and areas of habitat to be protected, and to set aside land for Growling Grass Frog habitat in PSPs.

Figure 3. *Growling Grass Frog (Litoria raniformis) (Photo by Peter Robertson © Museum Victoria)*

In order to protect areas of Growling Grass Frog habitat, DSE mandates a buffer up to 200 m either side (up to 400 m in total) of waterways in category 1 areas. Furthermore, there is a requirement within this habitat corridor that frog ponds (constructed wetlands) be included. The GGF Strategy requires a Conservation Management Plan be prepared for Merri Creek which will provide a detailed design of the habitat corridor.

The Conservation Management Plan for the PSP 25 and PSP 26 areas has not yet been completed. It will be included in the Precinct Structure Plans when finalised and will help to minimise the effect of development on Growling Grass Frog habitat.

As part of the growth corridor plan process, certain locations along Merri Creek were identified as locations where the buffer could be decreased due to topography and the area inundated in the 1 in 100 year flood event. Figure 4 illustrates the Merri Creek buffer as shown in the Growth Corridor plans and is utilised in the development of this Integrated Water Management Strategy.

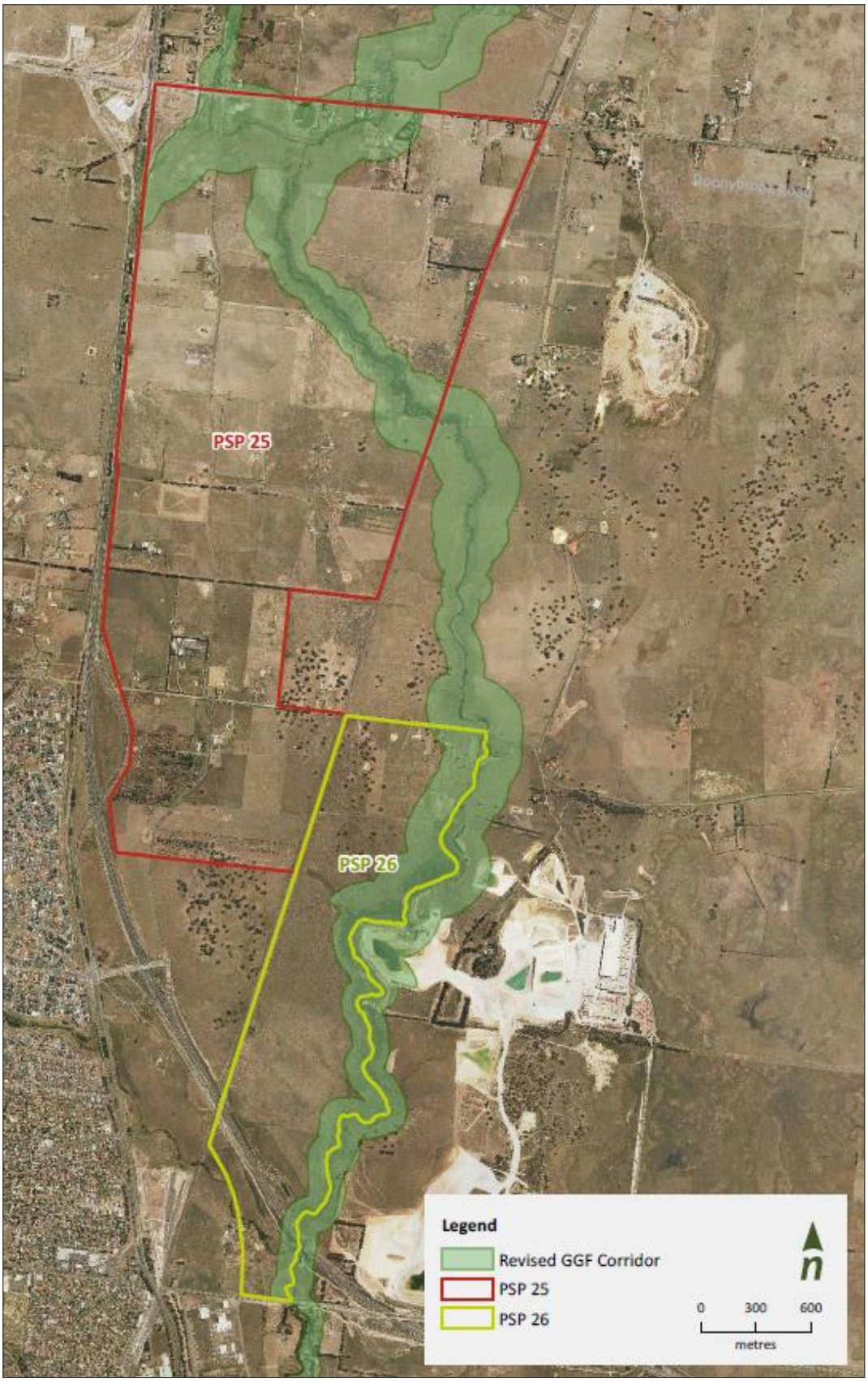

Figure 4. *Growling Grass Frog buffer through PSP 25 and PSP 26, as per the Growth Corridor Plan (2012)*

3 Stormwater runoff and flood management

The approach for managing the volume of stormwater runoff in the PSP areas is outlined in this section.

Stormwater in PSP 25 and 26 is intrinsically linked to runoff from the upstream Merri Creek Catchment, so a whole of catchment analysis has been conducted to identify the impact of urban development on flooding. There have been a number of prior drainage studies for parts of the Merri Creek catchment. Several of these have been incorporated into this analysis:

- *Melbourne Water, Merri Creek: Development of Land Subject to Inundation Overlay, Nov 2009*
- *Melbourne Water, Donnybrook Developer Services Scheme*, 2012.
- *BMT WMB, Kalkallo Creek Development Services Scheme, Dec 2011. A report prepared for Melbourne Water.*

3.1 Merri Creek catchment

Merri Creek is a major waterway in Melbourne's northern region. It is one of the Yarra River's main tributaries draining water from a catchment covering 396,000 hectares. Approximately 11,000 hectares of the catchment area is located upstream of PSPs 25 and 26. The headwaters of the Merri Creek begin in Wallan and flow in a southerly direction over basalt plains towards the PSPs in this study. After passing though PSP 25 and 26, the Merri Creek continues south before discharging into the Yarra River near Dights Falls.

For the purposes of our stormwater analysis, the Merri Creek catchment has been divided into the following subcatchments:

- Merri Creek Catchment – Upstream of PSP 25
- Merri Creek Catchment – Through PSP 25 and 26
- Merri Creek Catchment – Upstream of PSP 26
- Kalkallo Creek Catchment
- Donnybrook Area

Descriptions for each of the subcatchments are provided below, and their location is shown in Figure 5.

Merri Creek catchment – upstream of PSP 25
Upstream of PSP 25, the Merri Creek catchment drains over 11,000 hectares of land via a number of major tributaries. Current land use is predominantly agricultural, and includes the townships of Wallan and Beveridge. Melbourne's current Urban Growth Boundary dissects this subcatchment, including much of this currently agricultural area in the zone flagged for urban development.

Merri Creek catchment – through PSP 25 and 26
The Merri Creek Catchment within the PSP study area includes the area drained to Merri Creek between Donnybrook Road and the Melbourne-Sydney rail line, and between Summerhill Road and Craigieburn Road East. The confluences of Merri Creek with the major tributaries of Kalkallo Creek and Malcolm Creek occur within this subcatchment. Most of the PSP areas are within this subcatchment, with only small portions of the Kalkallo Creek, Malcolm Creek and Donnybrook subcatchments intersecting with the study area.

Merri Creek catchment – east of PSP 25 and 26
This subcatchment covers the area draining to the Merri Creek in the short section between PSP 25 and 26 (i.e. the Merri Creek between Melbourne-Sydney rail line and Summerhill Road). It covers approximately 430 hectares of mostly agricultural land.

Kalkallo Creek catchment
The Kalkallo Creek catchment covers an area of approximately 6,500 hectares to the north-west of PSP 25. A small portion (approximately 50 hectares) of the lower Kalkallo Creek catchment overlaps with the north eastern corner of PSP 25. Kalkallo Creek and its tributary, Mandalay Creek are the main waterways in the catchment. A major feature of the catchment's drainage is the Kalkallo retarding basin which is located upstream of Donnybrook Road. Sections of Kalkallo Creek are recognised as being regionally significant biosites, and include very important breeding sites and dispersal corridors for the Growling Grass Frog (DSE, 2011).

Donnybrook Area
The Donnybrook subcatchment covers approximately 520 hectares to the west of PSP 25. It represents the area investigated in Melbourne Water's Donnybrook Developers Drainage Scheme (MW, 2012). A small portion of the subcatchment (approximately 50 hectares) located in the north-west corner of the PSP. The area is currently in the final stages of investigation for the construction of a quarantine facility, which will require a revision of the Donnybrook Drainage Scheme.

Malcolm Creek catchment
The Malcolm Creek catchment drains approximately 1,900 hectares of urban and rural land to the west of the study area. Malcolm Creek discharges into Merri Creek downstream of the Hume Highway, near the southern end of PSP26. Only a small area of the catchment (37 hectares) intersects with the study area.

Amaroo development
The Amaroo development is located to the south of PSP 25 and to the west of PSP 26. The area is under development by the Goodman Group and the eventual use of this land will be commercial/ industrial. The hydrology of this parcel of land has consequences for the PSP as water drains from the PSP into the development, and then from the development back into the PSP.

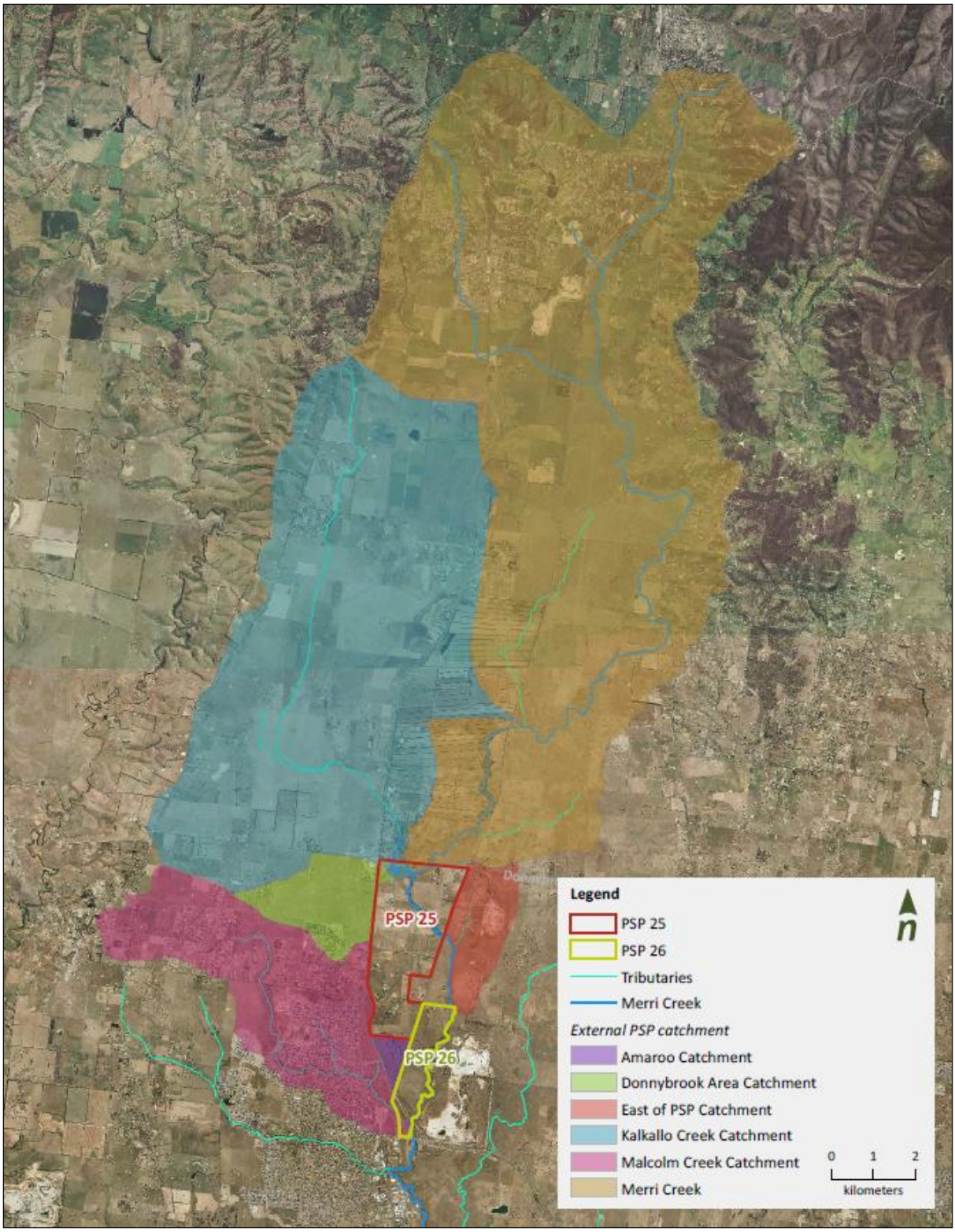

Figure 5. *Merri Creek subcatchments*

3.2 Modelling assumptions

Hydrologic and hydraulic modelling has been undertaken to provide the Growth Areas Authority (GAA) with an indication of the following:

- The impact of development in PSP 25 and 26 on the 100 year average recurrence interval (ARI) flows in the area
- Whether there is a need to retard flows in the PSP area, and
- The impact of development on the 100 year ARI Merri Creek flood extent within PSP 25 and 26.

Each of these outputs will serve to inform precinct structure planning. There are a number of assumptions that have been made throughout the modelling process as follows:

- LiDAR survey has been used to extract the HEC-RAS hydraulic model. As LiDAR does not penetrate water, pooled areas of water within the channel may under estimate the actual channel geometry. Feature survey will be required to enable detailed modelling and accurate interpretation of the 100 year ARI flood extent
- Dimensions of the multiple bridge and culvert crossings under the railway line and Donnybrook Road have been based on preliminary field measurements.
- Existing flood extents for Kalkallo Creek have been extracted from the existing flood extent layer provided by Melbourne Water and incorporated into the updated 100 year ARI flood extent for the subject reach of Merri Creek

3.3 Site inspection

A site inspection was undertaken by Alluvium on 15th June 2012 to identify features relevant to the site that may need to be considered in the hydrologic and hydraulic modelling and from a drainage, geomorphic or environmental perspective.

Physical dimensions of the following sites were recorded for hydraulic modelling:

- Hume Highway bridge crossing the Merri Creek
- Pedestrian crossing south of Craigieburn road
- Craigieburn Road bridge crossing the Merri Creek
- Summerhill Road bridge crossing the Merri Creek
- Railway crossing the Merri Creek
- Donnybrook Road bridge crossing Kalkallo Creek
- Brookville Road bridge crossing Kalkallo Creek

Manning's n is a measure of the roughness of the channel and was assessed at each of these sites and extrapolated along the study area drawing on knowledge of the area and aerial photographs. Manning's roughness co-efficient (*n*) was found based on the following:

- Merri Creek is generally a clean and winding stream with some pools, limited to medium density instream vegetation, riparian shrubs and some large wood present (see Figure 6, Figure 7, Figure 8). A corresponding Manning's *n* of 0.045 for the channel roughness has been determined.
- The left and right floodplains along the entire length of the study area consist of agricultural areas cleared for cropping and grazing. A corresponding Manning's *n* of 0.04 for the floodplain roughness has been determined.

Figure 6. *Merri Creek at the Donnybrook Road Bridge (left) and at the railway bridge downstream of Donnybrook Road (right). Manning's* n *at each of these sites was assessed to be 0.045*

Figure 7. *Merri Creek at Summerhill road crossing (left) and at the Craigieburn road crossing (right). Manning's n at each of these sites was assessed to be 0.045.*

Figure 8. *Kalkallo Creek at Donnybrook road crossing (left) and at Brookville drive crossing (right). Manning's n at each of these sites was assessed to be 0.045.*

3.4 Hydrology

A hydrologic analysis was undertaken to assess the effect of development on the volume of flow in the PSP area. The results of the analysis were used to determine:

- The impact of development on the 100 year ARI flows of the Merri Creek , and
- Whether there is a need to retard flows in the PSP area.

The hydrologic modelling software used in this study is RORBWin version 6.15 (Nathan 2010), a Windows version of the industry accepted RORB program (Laurenson & Mein 1997). RORB is a runoff and stream flow routing program that is used to calculate flood hydrographs from rainfall and catchment data. Specifically the RORB model was used to determine the existing and developed 100 year flood events for the Merri Creek and both its tributaries within the PSP area; Kalkallo Creek and Malcolm Creek.

Existing conditions model

There is approximately 18,000 hectares of the Merri Creek catchment upstream of PSP 25 and 26. Considering the large proportion of upstream catchment, it is appropriate to do a whole of catchment hydrologic analysis, as opposed to a localised analysis. The extent of the Merri Creek catchment and the location of the PSP area within this catchment is shown in Figure 9.

A hydrologic RORB model of the Merri Creek catchment has been undertaken by Melbourne Water as part of the "Merri Creek: Development of Land Subject to Inundation Overlay" (MW, 2009). This model formed the baseline existing condition model of the area and was also the basis of the developed conditions RORB model for PSP 25 and 26. The RORB parameters adopted in the existing conditions model are shown in Table 1.

Table 1. RORB parameters for existing conditions model

Rainfall station	Kalkallo
Initial loss	15 mm
Runoff Co-efficient:	0.6-0.7
Kc	30
M	0.85

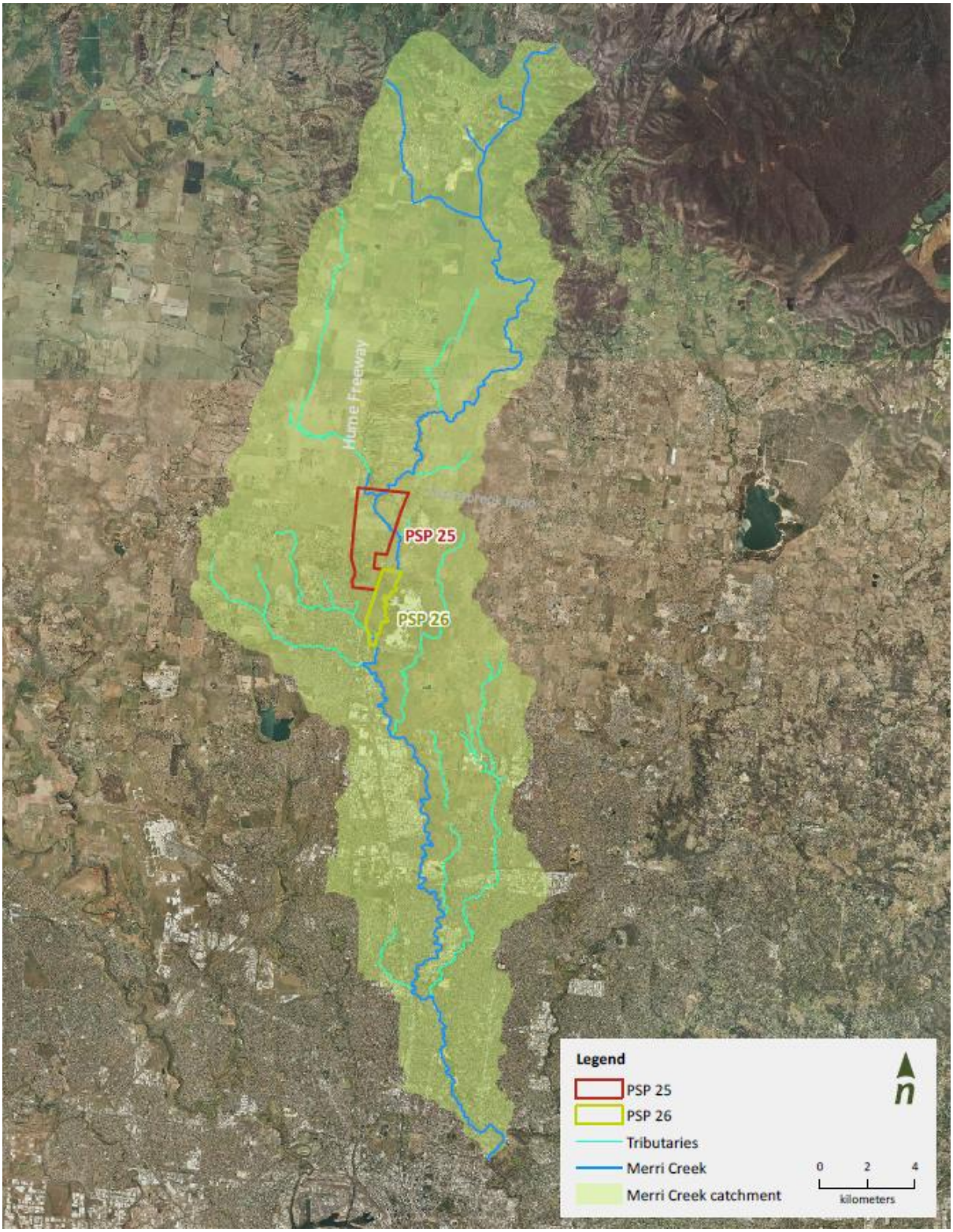

Figure 9. *Map of Merri Creek catchment used in existing conditions RORB model*

Post development model

A RORB model was developed to represent the ultimate developed catchment. This was achieved by:

- Altering the fraction impervious in the RORB model to reflect development
- Incorporating the Kalkallo Developer Services Scheme RORB model produced by BMT WMB

- Incorporating the Donnybrook Developer Services Scheme RORB model produced by Melbourne Water

The RORB parameters adopted for the post development model were the same as those used for the existing conditions model in Table 1.

The fraction impervious for developed conditions was based on ultimate land use. Figure 10 provides an illustration of the subcatchments within the wider RORB model that are local to the PSP area. The fraction impervious values of these subcatchments were varied accordingly between the existing conditions model and the post development model (Table 2).

Table 2. Fraction impervious of existing and developed RORB models

Sub-catchment	Area	Fraction Impervious
5A	5.18	0.1
6AP	1.94	0.725
6BP	0.46	0.9
7A	1.8	0.1
7AP	1.54	0.9
8A	0.9	0.1
8AP	1.27	0.9
9A	0.72	0.1
9AP	1.16	0.825
10AP	10.7	0.2
10BP	4.49	0.38
10CP	2.37	0.645
10DP	1.49	0.825
11A	0.39	0.84
11AP	0.37	0.9

The Kalkallo Creek catchment has undergone more recent development, which is not reflected in Melbourne Water's 2009 Merri Creek RORB model. A more recent hydrologic model was undertaken by BMT WBM on behalf of Melbourne Water for the "Kalkallo Creek Developer Services Scheme (Dec 2011)". The Kalkallo Creek RORB model was first prepared by Parsons Brinckerhoff in 2007 as part of a drainage scheme investigation for the Kalkallo and Beveridge areas. The Urban Growth Boundary was then extended, and the models were updated by Neil M. Craigie Pty Ltd (NMC). BMT WMB built on both these models in order to prepare the hydrology for the Kalkallo area. Melbourne Water has also prepared a Developer Services Scheme (DSS) for the Donnybrook area.

It is important to understand the hydrological impact, both locally and on a catchment wide scale, of retarding basins within the future urban growth area. The difficulty in understanding these impacts is that three independent RORB models with different sub area scales have been used. In order to overcome this issue the models were "coupled" together by extracting the output hydrographs from both the Kalkallo and Donnybrook RORB models and incorporated into the catchment wide Merri Creek model as a 'user defined input hydrograph'. Figure 10 illustrates the location of the Kalkallo Creek catchment and the Donnybrook DSS within the RORB model.

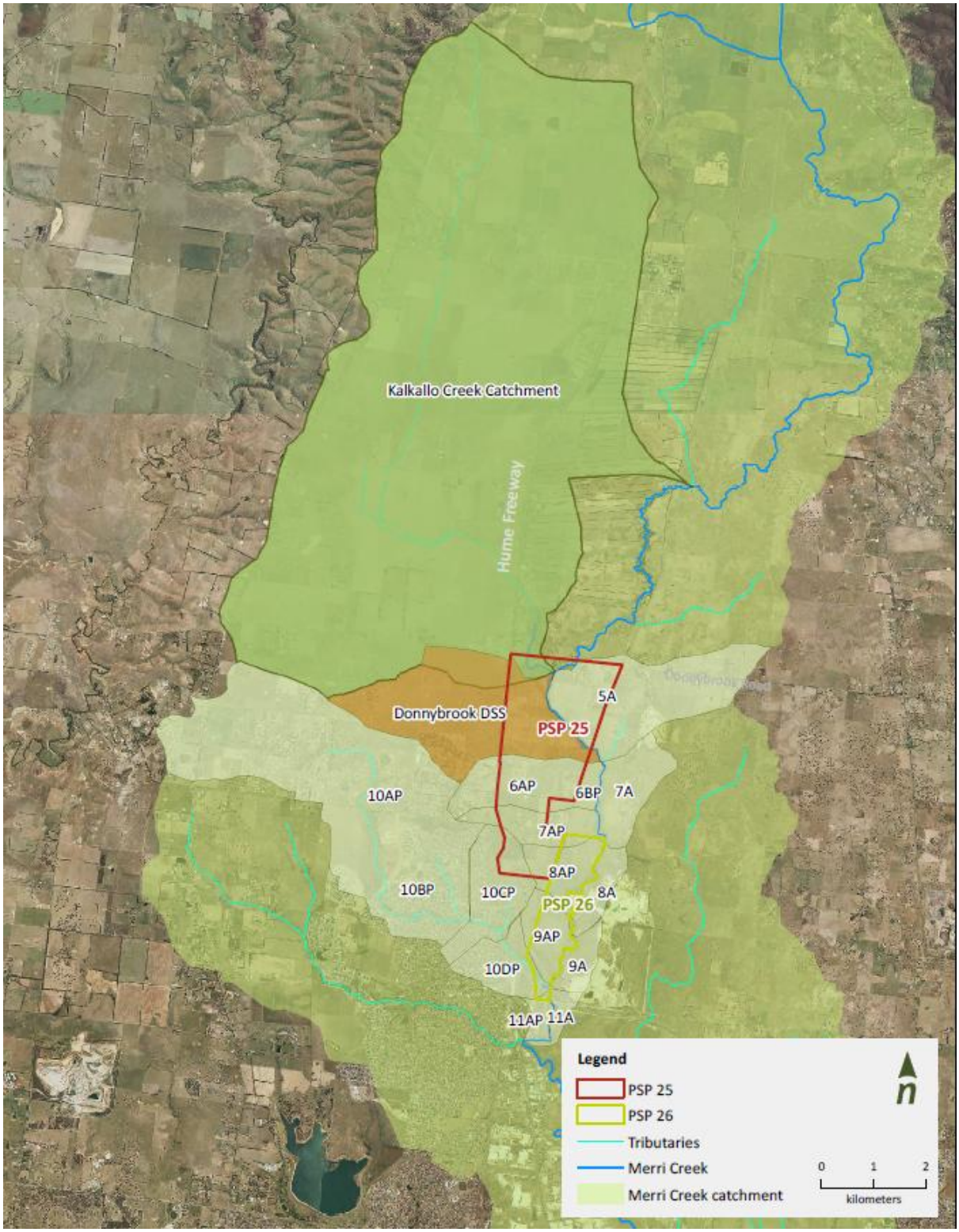

Figure 10. *Local RORB subcatchments within PSP area and location of Kalkallo DSS and Donnybrook DSS*

Flow outputs from the existing and developed RORB models at various locations are detailed in Table 3 below. These flows will be used in the subsequent HEC-RAS analysis.

Table 3. RORB modelled 100 year flows (9 hour storm)

Location	Existing conditions 100 year ARI flow (m^3/s)	Post development 100 year ARI flow (m^3/s)
Merri Creek - upstream of the Merri Creek/Kalkallo Creek confluence	86	92
Merri Creek - downstream of the Merri Creek/Kalkallo Creek confluence and input of Donnybrook Drainage Scheme	161	144
Craigieburn gauge	182	151
Merri Creek 2.5km south of Summerhill road	-	156
Merri Creek – downstream of Merri Creek / Malcolm Creek confluence	-	185
Merri Creek – 400m south of PSP 26 boundary	-	231
Cooper street gauge	306	282

The post development 100 year ARI flows in Table 3 are based upon no retardation within the PSP 25 and 26 area. A comparison with the existing conditions flow would suggest that no retardation in the PSP 25 and 26 area would actually deliver a reduction in peak 100 year ARI flows in the downstream Merri Creek system. The reason for this outcome is due to the change in land use and hydrologic response of the various catchments and tributaries within the Merri Creek. In particular the existing Kalkallo Creek retarding basin was constructed (in the 1970/80's) to hold back and delay peak rural flows as a downstream mitigation measure. In contrast urbanising the growth area increases the catchment response and allows the development hydrograph to pass through the system before the Kalkallo Creek basin outflow arrives (i.e. providing greater lag time between the two peaks).

Without a catchment wide analysis the benefits or impacts of retarding basins cannot be accurately assessed. Sometimes providing isolated retarding basins in sub-catchments can actually produce an increase in flow downstream if the timing, delay and coincidence of hydrograph peaks are not considered. Providing retarding basins (RB) in the area may in fact actually increase the peak 1 in 100 year ARI flow in Merri Creek. The potential effect of retarding basins on the hydrology of the Merri Creek system is illustrated in Figure 11. The peak developed runoff flow (with no RB) from the PSP area is approximately 3 hours before the peak of the Merri Creek arrives. In the instance where there is no retarding basin, the peak of the local runoff would already have passed, and would not contribute much to the overall Merri Creek flow.

When the retarding basin retains the local peak flow, however, it may end up contributing to the overall Merri Creek peak flow and increasing it by a magnitude of "a". As the retarding basin would be designed to delay and pro-long the outflow, the volume of local runoff that coincides with the Merri Creek peak flow would be almost doubled as compared to the non- retarded local runoff.

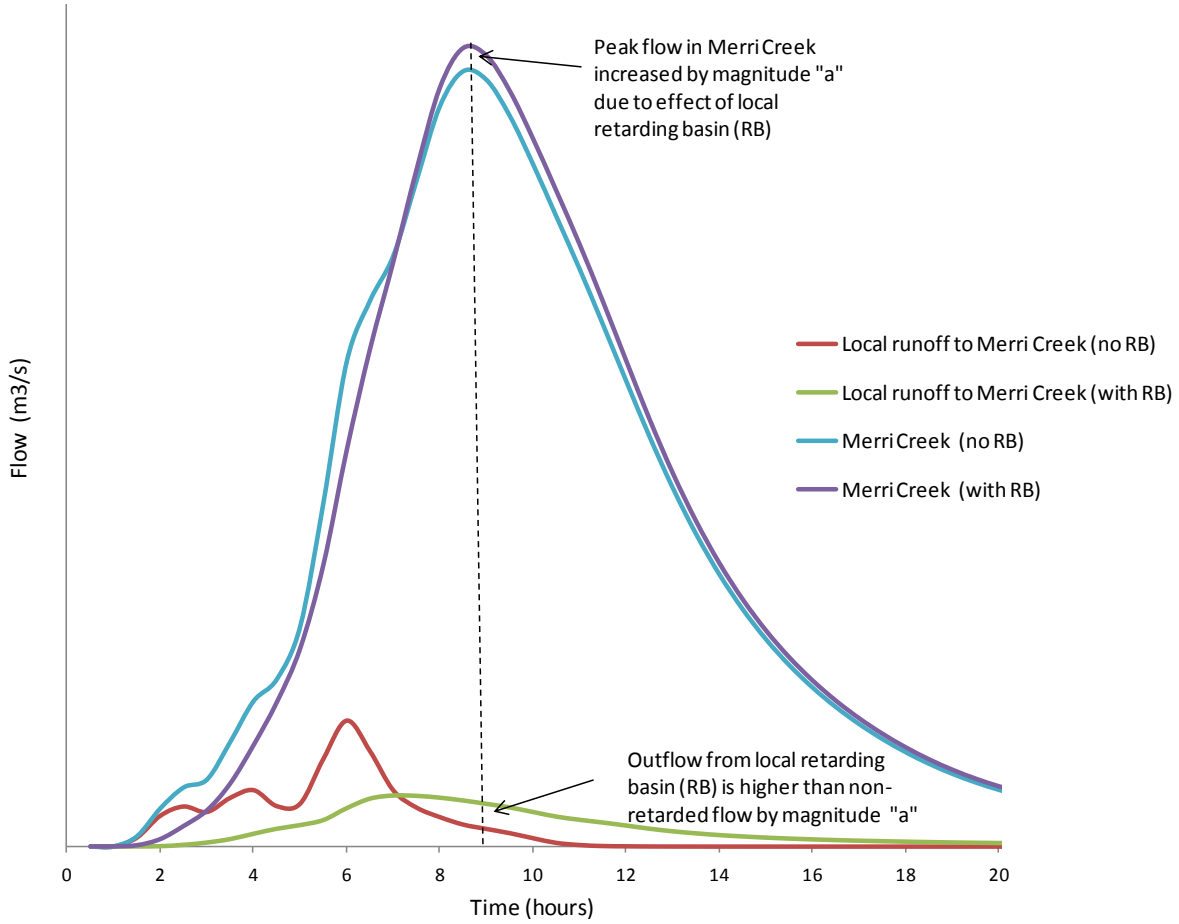

Figure 11. *Illustration of the effect of local retarding basins on the hydrology of the Merri Creek system*

3.5 Hydraulic analysis

A hydraulic analysis was undertaken in HEC-RAS to determine the impact of development in the PSP area on the 100 year flood extents of Merri Creek, Kalkallo Creek and Malcolm Creek.

HEC-RAS is a one dimensional steady and unsteady flow hydraulic software package that enables the determination of a number of hydraulic parameters including flood levels for a given range of input parameters. Cross sections of the study area were extracted from the digital terrain package 12d based on the LiDAR survey data provided by the Growth Area Authority. Dimensions of the multiple bridge and culvert crossings under the railway line have been based on field measurements as survey data of these structures was not available. Extracted cross sections were used to generate the HEC-RAS hydraulic models of each of the waterways (Figure 12 to Figure 14). Model parameters input in the HEC-RAS model (Table 4) were based on experience with similar waterways and the site inspection undertaken on the 15th June 2012.

Table 4. Hydraulic model (HEC RAS) parameters

Model	Upstream Boundary Condition	Downstream Boundary Condition	Hydraulic roughness (Manning's *n*)	
			Floodplain	Channel
Merri Creek	Slope (m/m) = 0.001	Slope (m/m) = 0.001	0.04	0.045
Kalkallo Creek	Slope (m/m) = 0.002	Known water surface= 217.33m	0.04	0.045
Kalkallo Creek tributary	Slope (m/m) = 0.01	Known water surface= 218.20m	0.04	0.045
Malcolm Creek	Slope (m/m) = 0.016	Known water surface= 177.12m	0.04	0.045

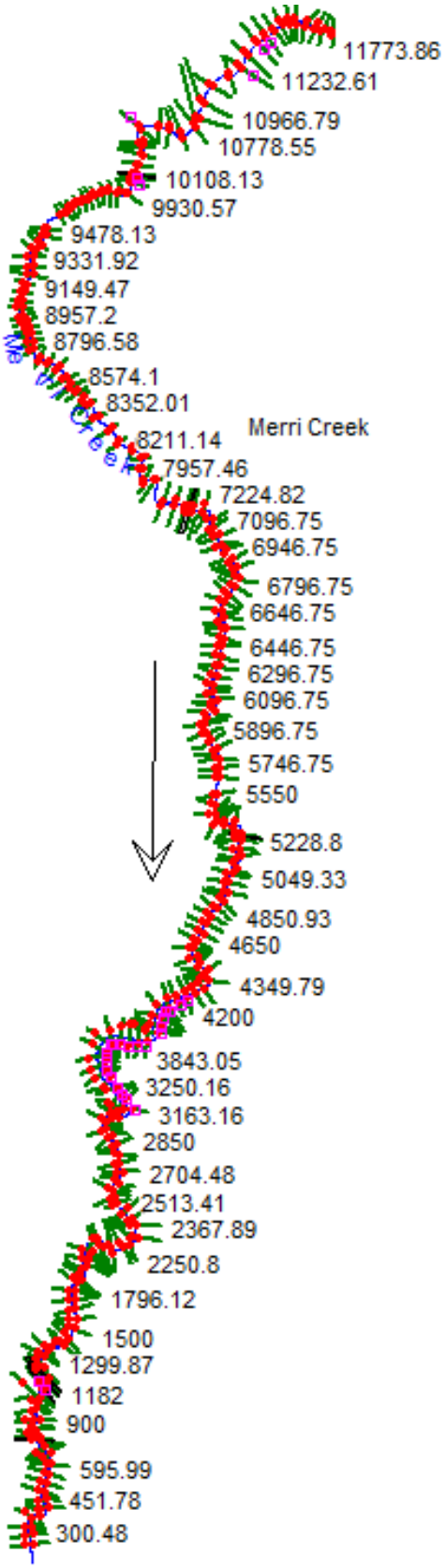

Figure 12. *Merri Creek HEC-RAS model*

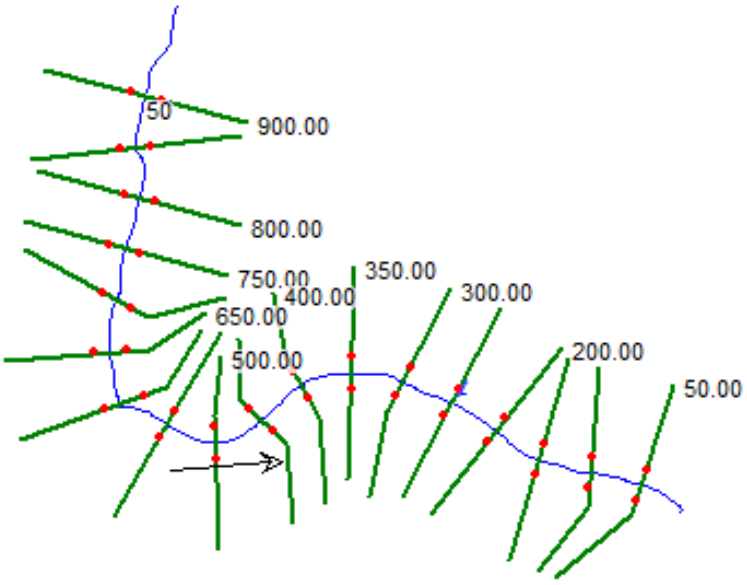

Figure 13. *Kalkallo Creek HEC-RAS model*

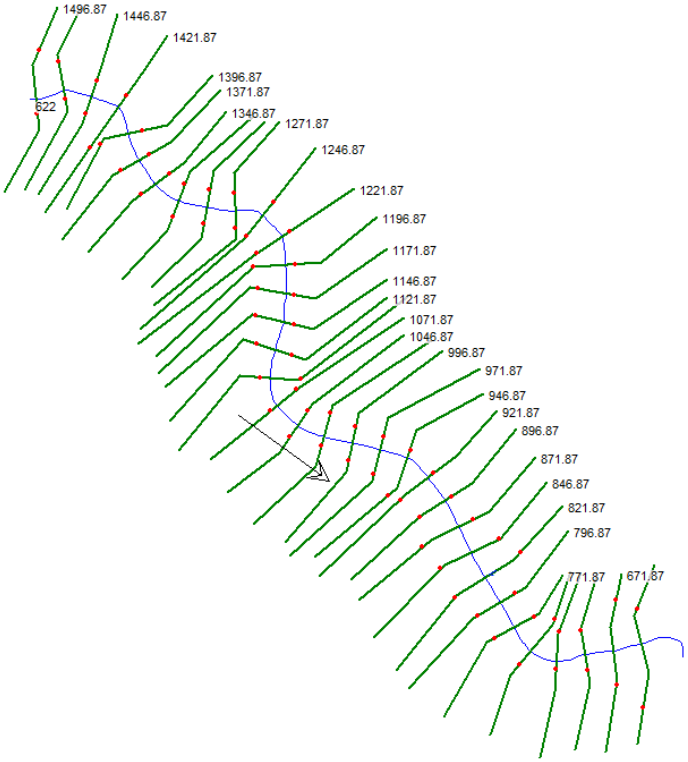

Figure 14. *Malcolm Creek HEC-RAS model*

Flows derived through the RORB modelling were input into the HEC-RAS model and used to determine the 100 year ARI flood extent for the fully developed flow scenario. Water surface levels produced in HEC-RAS were then exported into ArcGIS, a geographic information system program, and layered onto a digital terrain model (DTM) of the LiDAR to produce a map of the flood extent (
Figure 15).

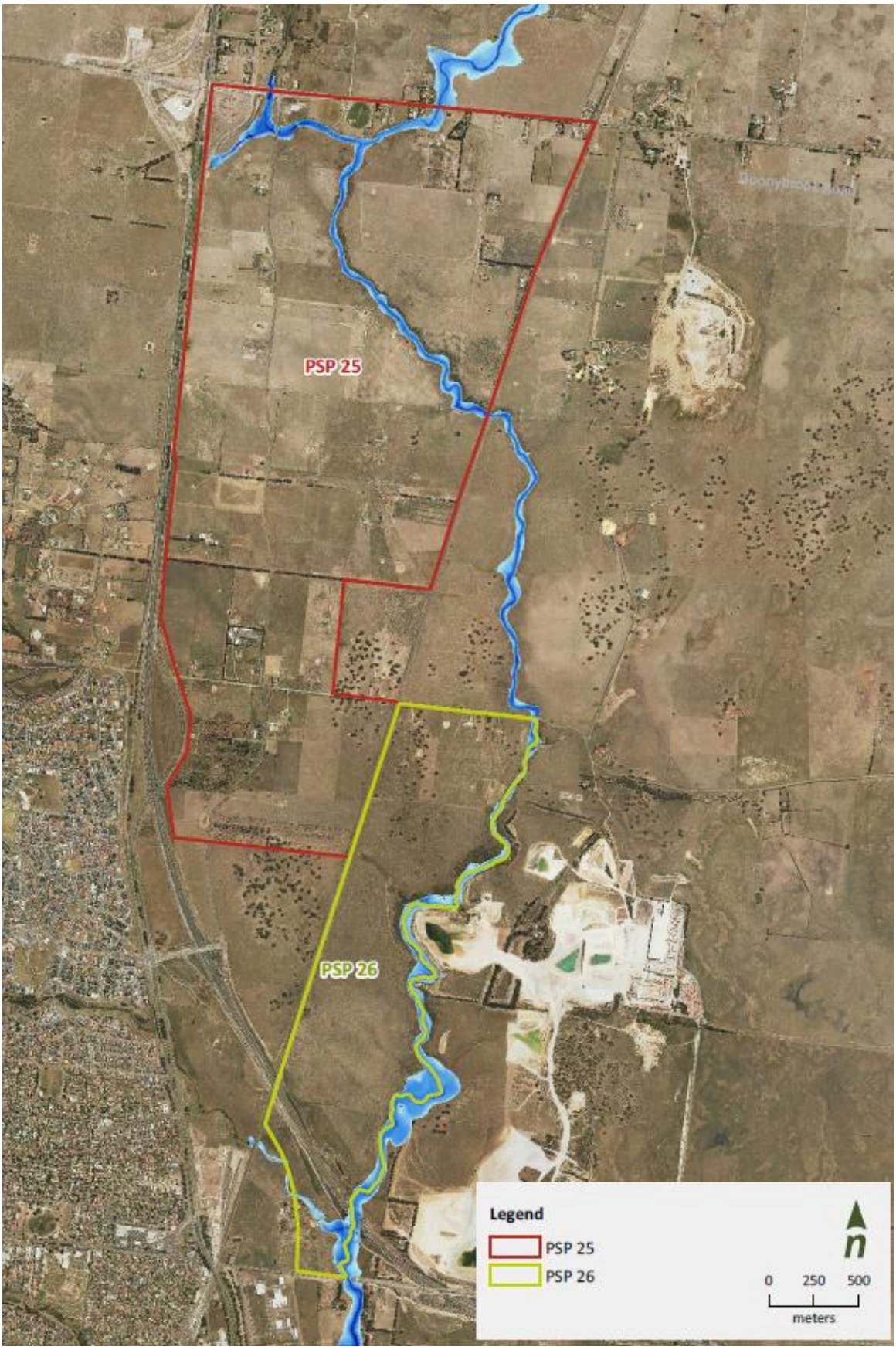

Figure 15. *100 year ARI flood extent for developed PSP area*

3.6 Recommendations and considerations

An initial hydrologic study of the wider Merri Creek catchment (as opposed to a localised PSP area study) has shown that developed conditions yield lesser flows than the current conditions. For this reason, it is recommended that the flows within PSP 25 and 26 not be retarded any more as the benefit is questionable and may potentially have an adverse effect on the timing of the peak flows. Therefore, from a technical perspective it appears that there is no need for retarding basins.

Melbourne Water has commissioned a study to rebuild the Merri Creek hydrologic model to accurately assess the impact of local development on the overall Merri Creek system. It is recommended that retarding basins not be included, and that the updated Merri Creek hydrologic modelling be used to confirm that retarding basins would not be appropriate in the area.

Instead of retarding basins, it is recommended that the railway crossings are upgraded and that a provision is made for 40 m wide drainage reserves.

Railway crossing

There are two options in relation to the railway crossings in the area: upgrade the infrastructure to allow the developed flows through the crossing; or retard the flow to pre-developed volumes and upgrade the culvert if necessary.

In order to accurately assess these options, field feature and level survey of the railway crossings will be required and the overall catchment analysis will need to be undertaken. There is potentially a benefit in retarding flows in that the existing infrastructure could be utilised and the process of upgrading the culverts could be avoided. The existing infrastructure, however, may not be deep enough to act as a control of the sub-divisional drainage, and may therefore require filling on the adjacent land or an additional lowered pipe crossing (therefore still an upgrade to the crossing).

Based on our preliminary hydrologic investigations, not retarding the flows would potentially provide better outcomes for the Merri Creek downstream of the PSP area. Our recommendation is that the culvert crossings are upgraded.

Retarding basins

It is recommended that flows are not retarded in the PSP area; however Melbourne Water is yet to confirm whether the catchment wide analysis will be acceptable. In the event that on site retardation to pre-development flows is required, a preliminary analysis of the sizing and location of retarding basins has been undertaken (Table 5). It is proposed that retarding basins would be best served on the upstream side of the railway, under the assumption that the existing railway infrastructure would withstand the pre development flow.

Figure 16 illustrates the proposed retarding basin locations and the recommended size (ha). The Goodman Group is also in discussions with Melbourne Water and VicRoads concerning the location of a retarding basin for their development. The current proposed location of this basin is also shown in Figure 16.

Table 5. Sizing of retarding basins within PSP 25 and PSP 26

Retarding Basin	Catchment area upstream of retarding basin (ha)	Surface area (ha)	Volume of storage (m^3)	Total land required (ha)
1	173	8	93,675	8.8
2	53	3	25,800	3.5

Local level drainage
It is recommended that the flows are not retarded and that drainage reserves are included in the road network design in areas where flows are greater than 5.5 m3/s.

It is recommended that the drainage strategy for the proposed internal development be based on the major/minor approach. The minor drainage system is generally a system of underground drainage pipes capable of carrying the runoff from minor storm events; which are typically storms with a maximum 1 in 5 year average recurrence interval (ARI). The runoff from major storms is conveyed by a combination of planned and unplanned networks, including road networks and linear open spaces, and this is known as the major drainage system. The major drainage system will be designed to accommodate a 1 in 100 year average recurrence interval event.

The subdivisional drainage will be constructed to standards agreed with the City of Whittlesea Council and Melbourne Water in accordance with the minor/major drainage system philosophy. The Hume City PSP can accommodate for the conveyance of the major and minor events through the provision of roadways or drainage reserves. The need for drainage reserves can be minimised through careful consideration of the orientation of local road reserves. If designed correctly, the local road reserves could function as overland flow paths.

Melbourne Water has safety criteria that dictate the maximum overland flow that can be safely conveyed in a road reserve. It is recommended that any flow outside of this range be accommodated for with a drainage reserve. Based on a typical 22m and 25m wide industrial road reserve, with a range of grades from 0.5 – 2%, the maximum overland flow that can be conveyed via a road reserve ranged from 5 – 5.5 m3/s.

An approximation of the expected internal overland flows was made to determine which areas of the PSP require drainage reserves. A total of four of the sub catchments within the PSP area were found to have an overland flow greater than 5.5 m3/s, therefore require a drainage reserve. The major/ minor drainage network would be sufficient to convey the flows in the remaining sub catchments The approximate location of each of the reserves is shown in
Figure 17, and the dimensions required for each of the drainage reserves in shown in Table 6. It is recommended that a minimum width of 40 m be adopted for all drainage reserves, likely to be a minimum corridor width required by Melbourne Water for constructed waterways so that hydraulic, river health and maintenance needs can be accommodated.

Table 6. Drainage reserve requirements

Catchment	Area of subcatchment (ha)	Slope (%)	Rate of flow of runoff (m3/2)	Length of Drainage Reserve(m)	Hydraulic Width (m)	Width of Drainage Reserve(m)
C	79	1	11.6	200	20	40
E	185	2	25.29	300	24	40
H	71	3	13.16	300	21	40
I	29	2	6.12	300	18	40

Retention of more frequent flows
The drainage strategy has catered for the effect of development on the larger flows, less frequently occurring flows. The increased imperviousness in the area due to development will also have an effect on the more frequent, lower volume flows. Under natural conditions, these flows would infiltrate into the ground. However under developed conditions, these flows will drain to the creek at a more regular basis.

It is recommended that the drainage strategy incorporate distributed bio-retention systems throughout the development to retain the lower, more frequent flows and protect the receiving waterways.

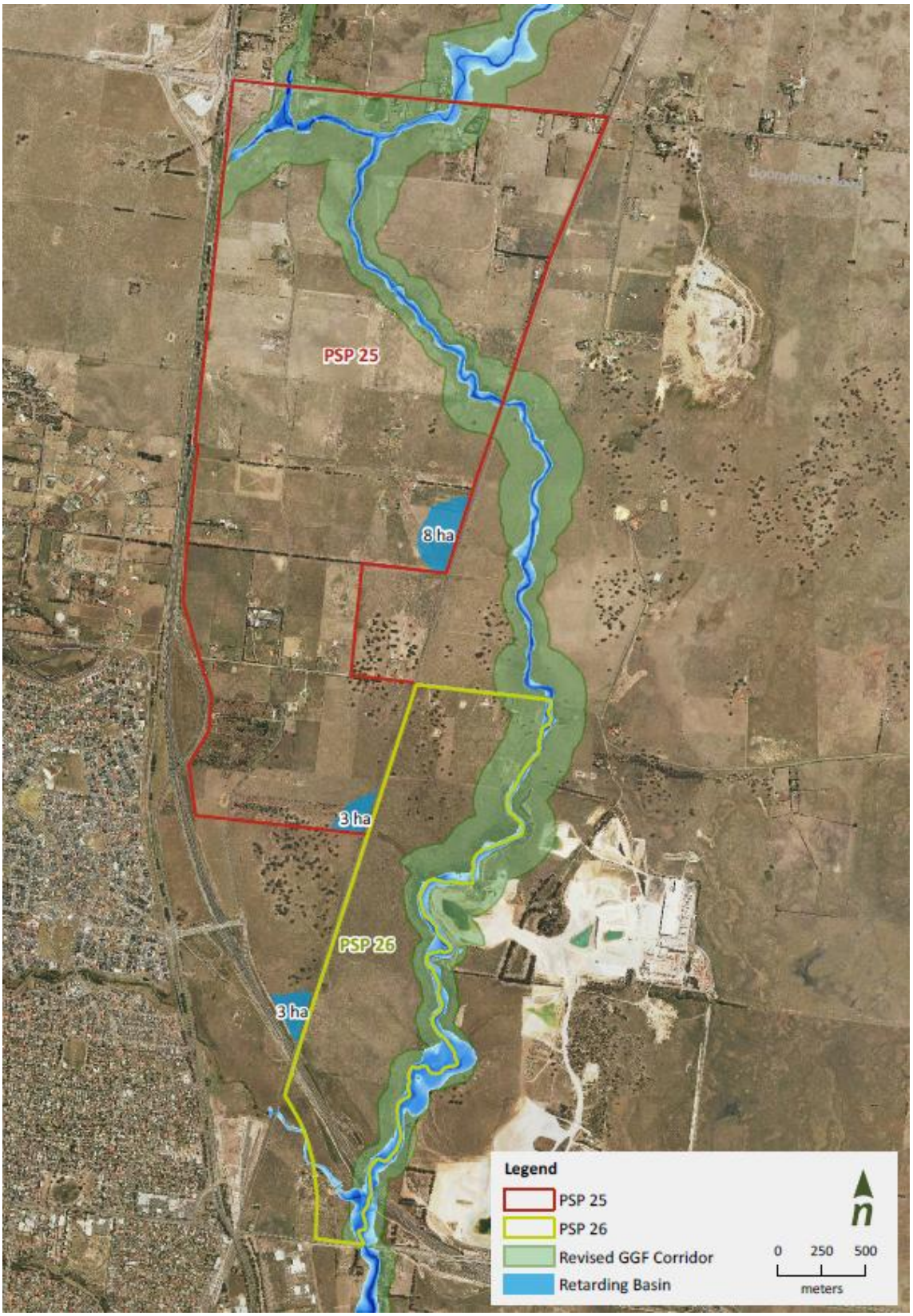

Figure 16. *Map of recommended retarding basin location and size (ha).*

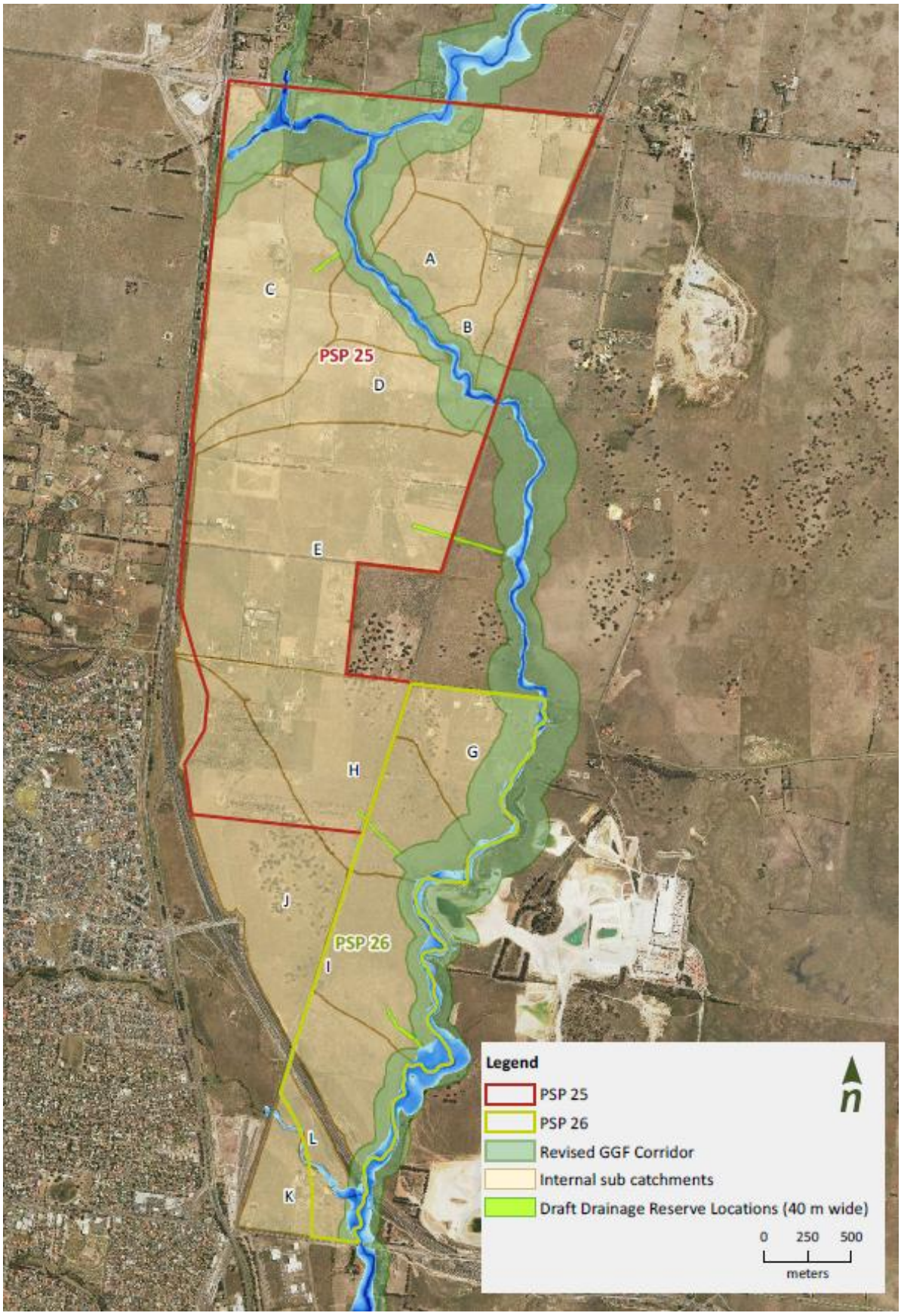

Figure 17. *Map of internal sub catchment locations and recommended drainage reserve locations*

4 Stormwater quality

Water quality treatment is undertaken principally to protect the natural waterways and then the receiving environment (Port Phillip). The key waterways associated with this project are Merri Creek (tributary of Yarra River); Kalkallo Creek (tributary of Merri Creek); and Malcolm Creek (tributary of Merri Creek).

The objective of this section is to design a water quality treatment system that meets the best practice overall pollutant reduction targets prior to discharge into the receiving waterways.

The location and number of stormwater quality measures will be influenced by the Growling Grass Frog Conservation Management Plan (CMP) as treated stormwater is expected to be the supply source for the wetlands (see Section 4.4).

4.1 Stormwater quality targets

The stormwater treatment strategy for PSP 25 and 26 has been prepared based on meeting the best practice pollutant reduction targets:

- 70% removal of the total Gross Pollutant load
- 80% removal of the total Suspended Solids
- 45% removal of the total Nitrogen
- 45% removal of the total Phosphorus

4.2 Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) provides a holistic approach to stormwater management by focusing on the integration of urban development with the protection of the water cycle. The key principals of WSUD as stated on the Melbourne Water website are:

Protect natural systems - protect and enhance natural water systems within urban developments. Promoting and protecting natural waterways as assets allows them to function more effectively and supports the ecosystems that rely on them.

Integrate stormwater treatment into the landscape - use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments. The natural stormwater drainage system can be utilised for its aesthetic qualities within parklands and walking paths, making use of natural topography such as creek lines and ponding areas.

Protect water quality - improve the quality of water draining from urban development into receiving environment. Through filtration and retention, water draining from urban development can be treated to remove pollutants close to their source. This approach reduces the effect that polluted water can have upon the environment and protects the natural waterways.

Reduce runoff and peak flows - reduce peak flows from urban development by local detention measures and minimising impervious areas. Local detention and retention enables effective land use for flood mitigation by utilising numerous storage points in contrast to the current practice of utilisation of large retarding basins. This approach subsequently reduces the infrastructure required downstream to effectively drain urban developments during rainfall events.

Add value while minimising development costs - minimise the drainage infrastructure cost of the development. The reduction of downstream drainage infrastructure due to reduced peak flows and runoff minimises the development costs for drainage, whilst enhancing natural features such as rivers and lakes that add value to the properties of the area.

4.3 Stormwater quality approach

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was developed to determine the stormwater quality strategy. The model estimates the volume of pollutants produced in the catchment without treatment, and pollutant load generated in the catchment after stormwater treatment.

Melbourne Water has prepared a MUSIC model for the Donnybrook DSS design, and this model has been incorporated into the stormwater quality modelling for PSP 25 and 26.

Two stormwater quality scenarios were developed in accordance with Melbourne Water MUSIC guidelines.

- **Scenario 1:** Donnybrook DSS design and treatment within the Merri Creek corridor to meet the best practice pollutant reduction targets.
- **Scenario 2:** Donnybrook DSS design and a combination of treatment within the Merri Creek corridor (40-60% of the stormwater treatment) and the use of distributed WSUD treatment measures to meet the best practice pollutant reduction targets.

A preliminary estimate has been made of the surface area required in each scenario (Table 7). The reference rainfall station used was the Melbourne Regional office gauge.

Table 7. MUSIC modelling results

		Scenario 1		Scenario 2		
Location (*refer to Figure* 17*)*	**Catchment area (ha)**	**Stormwater treatment type**	**Surface area of treatment within creek corridor (ha)**	**Stormwater treatment type**	**Surface area of treatment within creek corridor (ha)**	**Surface area of treatment within the development (ha)**
Catchment A and B	49	Wetland	0.70	Wetland	0.50	
		Sediment basin	0.07	Sediment basin	0.05	
				Bioretention		0.06
Catchment E	180	Wetland	5.20	Wetland	4.40	
		Sediment basin	0.52	Sediment basin	0.44	
				Bioretention		0.58
Catchment G	46	Wetland	2.20	Wetland	2.00	
		Sediment basin	0.22	Sediment basin	0.20	
				Bioretention		0.25
Catchment H	102	Wetland	1.80	Wetland	1.50	
		Sediment basin	0.18	Sediment basin	0.15	
				Bioretention		0.18
Catchment I	52	Wetland	1.20	Wetland	1.00	
		Sediment basin	0.12	Sediment basin	0.10	
				Bioretention		0.12
Catchment J	32	Wetland	0.74	Wetland	0.62	
		Sediment basin	0.07	Sediment basin	0.06	
				Bioretention		0.07
Catchment K	27	Wetland	0.65	Wetland	0.50	
		Sediment basin	0.07	Sediment basin	0.55	
				Bioretention		0.07
Total (ha)	**488**		**13.7**		**11.57**	**1.3**
% total area			**2.8%**		**2.3%**	**0.3%**

4.4 Recommendations and considerations

There exists an opportunity to integrate the stormwater treatment and the source of water for the Growling Grass Frog ponds. There is also an opportunity to create a more distributed stormwater treatment system throughout the development.

Integration of stormwater wetlands and Growling Grass Frog habitat

It is recommended that the frog ponds (constructed wetlands) be watered with treated stormwater, marrying the ecological requirements and the integrated water management. This integrated approach has been recommended and approved for Lockerbie PSP, a development site on the Merri Creek directly north of PSP 25. This approach is also under consideration for the Rockbank North PSP on Kororoit Creek, another creek that has a protected habitat requirement for the Growling Grass frog. Although the PSP 25 and 26 Conservation Management Plan (CMP) will ultimately dictate the location and number of frog ponds, it is recommended the PSP 25 and 26 be designed similarly to the Lockerbie and Rockbank North precincts.

The Conservation Management Plan (CMP) for the Growling Grass Frog in the Rockbank North area was prepared by Ecology Partners. They identified the following habitat requirements for Growling Grass Frogs:

- Permanent or semi-permanent still or slow flowing waterbodies;
- Emergent vegetation for protection from predators;
- Floating vegetation to provide suitable calling stages for adult males and breeding sites; and
- Terrestrial vegetation (grasses, sedges), rocks and other debris for foraging, dispersal and over-wintering sites.

Through the preparation of an integrated water management plan for the Rockbank North area, CPG Consultants and Ecology Partners recognised that there was an opportunity to integrate the stormwater management and the frog habitat. The requirements for the Growling Grass Frog wetlands (
Figure 18) are similar to that of a stormwater treatment constructed wetland. The requirements are specified in the CMP are as follows:

- Pre-treatment zone for primary treatment of surface runoff (Minimum surface area of 2000 m²).
- Emergent vegetation zone, similar to the 'macrophyte zone' in constructed wetlands (minimum surface area of 2400 m²)
- Area of open water and extensive floating vegetation (minimum surface area of 800 m²). This area will contain the highest quality water and be suitable for frog reproduction.

A distance of 300m between constructed frog wetlands is recommended in the Sub-Regional Strategy for the Growling Grass Frog (DSE, 2011). Based on this requirement, a map of the draft frog pond locations has been prepared (
Figure 19). The frog ponds are within the Growling Grass Frog buffer, and therefore do not require further land take There is a need to marry the requirements for the Growling Grass frogs with the topographic limitations as to provide a sustainable feed source to the frog ponds. The location and configuration of the Growling Grass frog ponds should be further explored in the preparation of the Growling Grass Frog Conservation Management Plan, and the water quality and quantity issues will be addressed at this stage.

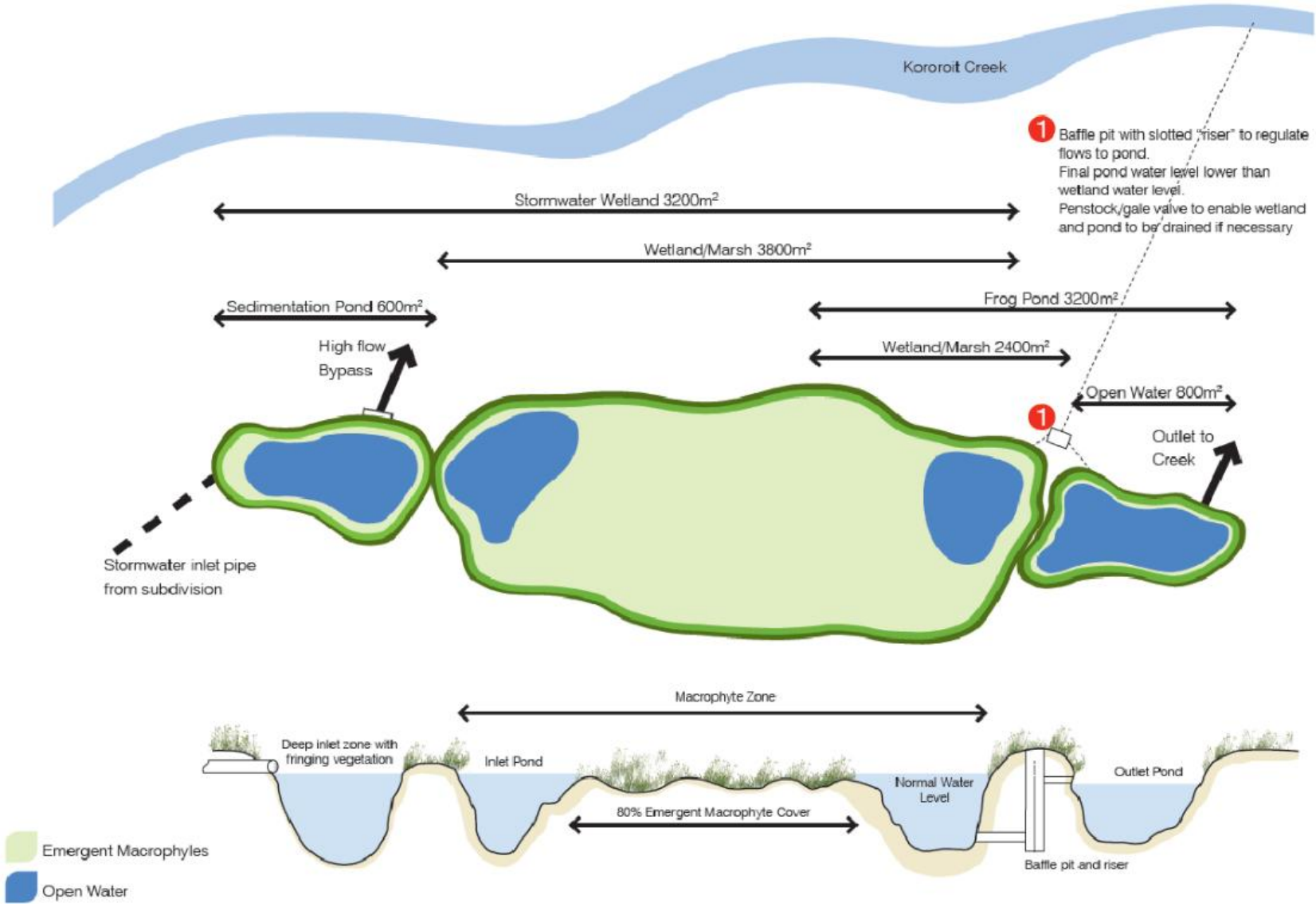

Figure 18. *Concept of integrated frog pond and stormwater treatment (Rockbank North PSP, CPG, 2012)*

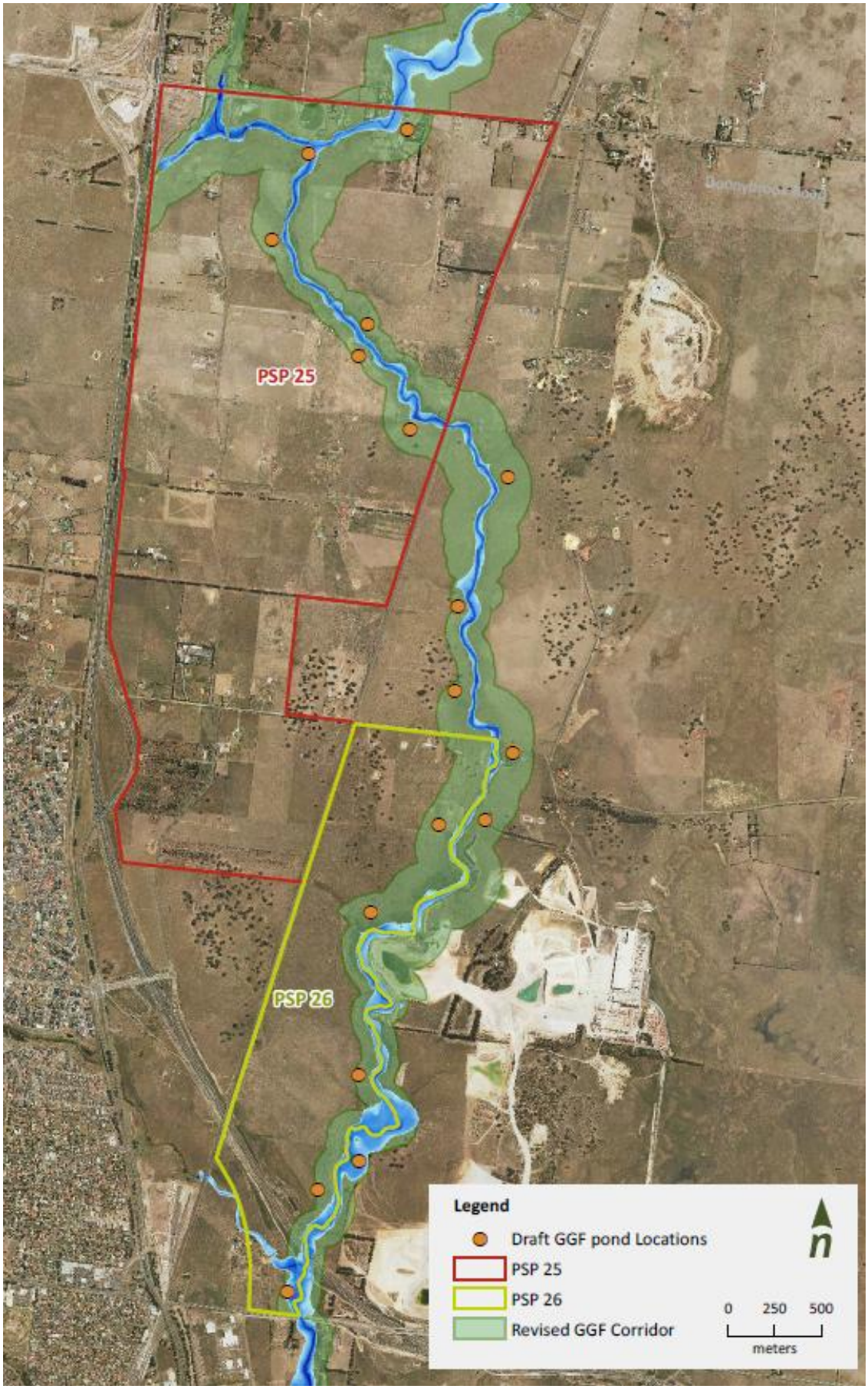

Figure 19. *Draft Growling Grass Frog pond locations*

Distributed stormwater treatment system

A consideration in minimising land take and designing an appropriate stormwater strategy is the distribution of lot, precinct and regional systems (Figure 20).

Site Elements	Precinct Elements	Regional Elements
• allotment density and layout	• Street layout and streetscape	• public open space • multiple use corridors
• on- site retention (infiltration) • porous paving • sand filter – butter strip • grassed or vegetated swales • bio-retention system • rain garden	• precinct retention (infiltration) • porous paving • sand filter • buffer strip • grassed or vegetated swales • bio-retention system • urban forest	
• on- site detention • rainwater tank for stormwater reuse	• constructed wetlands and treatment ponds • stormwater reuse	• constructed wetlands & treatment ponds • stormwater reuse

Figure 20. *Various scales of stormwater treatment (Melbourne Water , 2012)*

Although it is not mandated for industrial developments to incorporate streetscape treatments, there are many benefits of the option such as (Melbourne Water, 2012):

- **Improved protection of waterways**: As the treatment is distributed throughout the catchment, it decreases the risk of stormwater entering the waterway untreated.
- **Distributed risk**: The failure of one treatment will not have as great an effect on the overall system.
- **Amenity values**: Many of the treatments, such as raingardens, enhance the natural environment and add value to the landscape.

There also exists an opportunity to incorporate WSUD treatments into the open space that is required for setbacks from the transmission line. This would provide an opportunity to improve the quality of the stormwater entering the Merri Creek in the northern area of the PSP, improve the aesthetic of the area and also utilise the otherwise ineffective open space.

5 Fit for purpose water sources

An important part of the development of PSP 25 and 26 is the supply of reliable and fit for purpose water, and the treatment of waste and stormwater from the region.

Traditionally water sources are managed individually, and challenge in new developments (residential and industrial) is to move away from this single source approach and integrate water issues as much as possible.

The movement towards integrated water management is supported through the current State government's policy on urban water management. They have set up the Office of Living Victoria, which aims to:

- *Establish Victoria as a world leader in liveable cities and integrated water cycle management*
- *Drive generational change in how Melbourne uses rainwater, recycled water and stormwater*
- *Drive integrated projects and developments in Melbourne and regional cities to use rainwater, recycled water and stormwater to provide Victoria's next major water augmentation (to be used for non-drinking purposes).*

To analyse the water supply and demand of PSP 25 and 26, the following inputs were used:

- Climate data from the Bureau of Meteorology
- Discussion with the 'Sustainable Growth Planning' team at Yarra Valley Water
- Demand data in industrial areas in Yarra Valley Water's region
- Maps of mandated recycled water areas within Kalkallo region
- Guidelines of impervious and stormwater runoff from Melbourne Water, and
- Past projects by Alluvium on supply and demand scenarios

5.1 Integrated water management approach

In recent years, drought and its impact on water storage levels, and continuing urban growth has become a major driver for improved water resource efficiency within the Australian water sector. This has led to the development of new and innovative ways to meet the water needs of our urban centres. A key element of this change has been the emergence (and, in some cases, re-emergence) of decentralised management strategies to supplement water demands and improve waterway health.

A conceptual model for integrated water management that describes the linkages is provided in Figure 21.

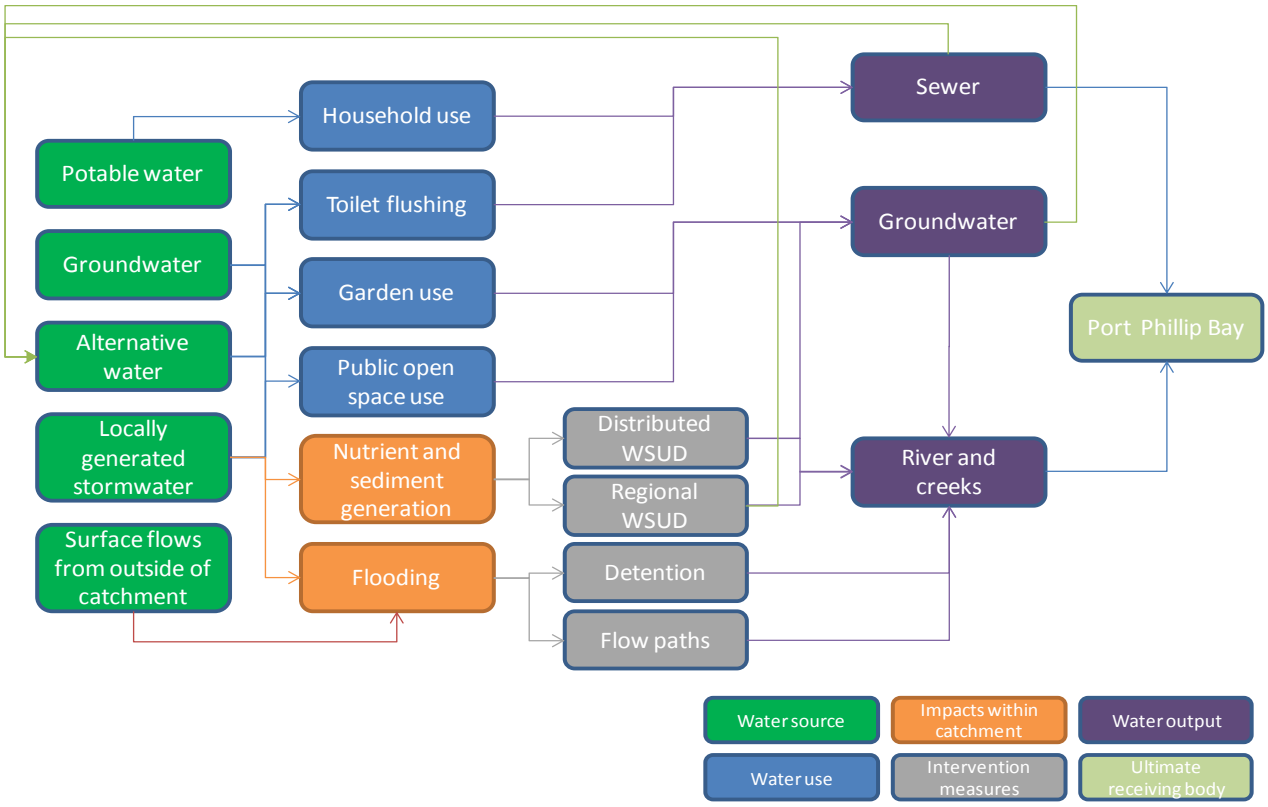

Figure 21. *Integrated water conceptual framework (IWMP, PSP 40, Alluvium 2011)*

5.2 Demand

Water demand for the region is based on the projected land use and associated water demand for each land use. Yarra Valley Water (2012), estimate that industrial areas consume approximately 5000 litres / hectare / day. The relevant land uses of each PSP are as follows:

- For PSP 25, industrial areas constitute 417 hectares of a total 638 hectares. The remaining area is allocated to farm use (FZ) and creek setbacks.
- For PSP 26, industrial areas constitute 50 hectares of a total 197 hectares. The remaining area is allocated to the Hume Highway and creek setbacks.

The assumption for the demand in this area is that any land not zoned industrial will not require water (in a traditional supply sense and beyond rainfall on the site). Yarra Valley Water's estimate of rural demand was 1300 litres / hectare / day, well below the industrial demand.

5.3 Supply

An analysis of stormwater potential indicates that PSP 25 has a potential for 1800 megalitres per year, and PSP 26 has the potential to generate 215 megalitres per year. This is based on the runoff generated from the industrial areas alone, with a factor of 0.9 impervious and 0.7 runoff coefficient applied to the annual rainfall of 685 millimetres a year.

If the English Street Precinct (estimated area of 103 hectares) was developed with residential zoning, an estimated 2575 new houses would be built in this PSP. The additional water demand for those residential developments would be approximately 408 megalitres per year.

The stormwater quality treatment (see Section 4) considered a series of wetlands to treat the stormwater pollutant loads, with approximately 17 wetlands spread across the catchment. These wetlands could be enhanced with some stormwater harvesting options (as per other examples like Royal Park, Parkville), or harvesting could occur closer to the source, for example at the site of a large warehouse. The location and size

of potential stormwater harvesting systems has not been investigated at this stage, but there is a clear potential for stormwater to supply some of the demand in this region. This proposed work would conceptually be as follows:

- Investigate options for harvesting at the industrial roof scale verses the precinct scale
- Prepare MUSIC model (catchment/supply)
- Establish demand opportunities and scenarios
- Determine Storage options (including above and below ground and adjacent to roofs)
- Indicative “order of cost” estimate
- Size wetland and treatment train
- Review maintenance implications and relationship
- Review opportunities to co-locate infrastructure
- Review opportunities to obtain multiple benefits from infrastructure
- Stakeholder meeting to discuss roles and responsibilities

Yarra Valley Water have indicated that while this area is not a mandated recycled area, a recycled main runs along Brookfield drive through the PSP 25 and there is potential to supply industrial developments (Figure 22). There are several regions outside of the study area that are mandated recycled water areas. Anecdotally there is an excess of recycled water supplied to that this is demanded. On this basis, the recommendation for PSP 25 and 26 is that recycled water should be considered to meet some of the demand for this region.

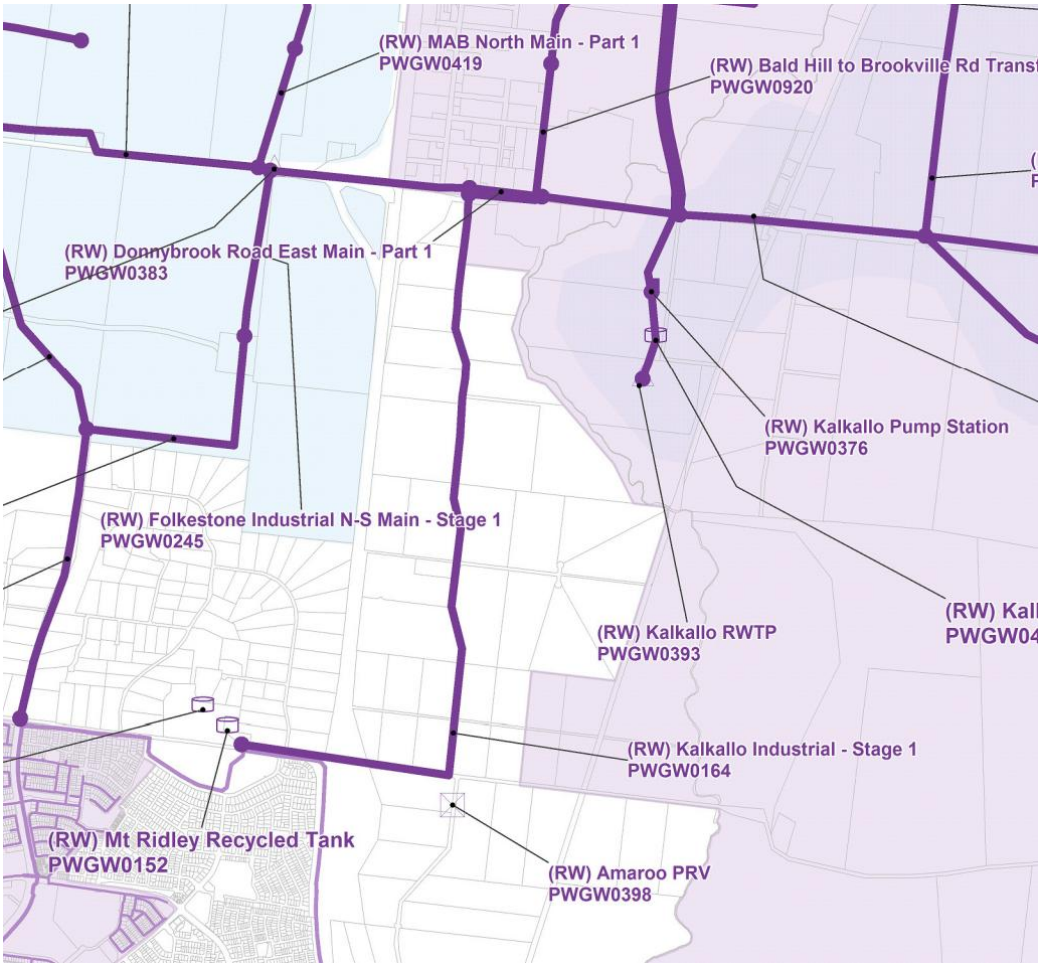

Figure 22. *Location of recycled water main within PSP 25. Note: Plans have not been updated to show that the Kalkallo RWTP is now located on Langley Park Drive. (Yarra Valley Water, 2012)*

A potable supply is assumed to be delivered to this region and can meet all of the demands if required. Though any option that includes only potable supply would be in contradiction to earlier comments about an integrated water approach, and add pressure to the centralised water supply system and a government direction that is looking to diversify water management due to population growth and climate change. In light of the potential to harvest stormwater, tap into the recycled water mains line, and use potable water, there is no need to consider greywater as a supply option. Greywater is a more complex water source and on the basis that there is ample supply, there is no need to consider a water source with more complexity in treatment and storage.

5.4 Optimal mix of water sources

The opportunity exists in this region to look for potable substitution options and a mix of supply options.

Based on the above supply options, there is potential for stormwater and recycled water to be used to significantly reduce the use of potable water. This analysis has not covered the detail of the supporting infrastructure and the associated costs of various supply systems. The assumption is that the optimal mix of water sources will be determined at a later date, with more information on the needs of industry and a detailed assessment of stormwater and recycled water costs and benefits.

In terms of when the decision on the optimal mix of water supply options should be undertaken, it should be before any major water infrastructure decisions are made, and before the design and construction of major and minor roads are completed. The ability of water authorities, councils and corporations to retrofit water infrastructure is limited and expensive in comparison to building in the options and flexibility prior to development.

The process of determining how best to incorporate alternative supplies into PSP 25 and 26 would be as follows:

- Refine the water demand through a) market research on possible tenants and respective water demands, and b) review of comparative data from an actual industrial area in YVW's region.
- Confirm recycled water main lines and pumping stations
- Discuss possibility of recycled water supplies into PSP 25 and 26 with YVW
- Refine possible stormwater quality wetland locations and sizes
- Consider size of storages in the context of catchment and rainfall scenarios
- Consider possibility of stormwater harvesting tanks to be backed up with recycled water in dry periods
- Optimise the scenario of stormwater harvesting based on the size of the tank, water demand, and cost.

A key issue to be considered in the supply of various water sources is the need to introduce flexibility into the system from 'day one'. There will be significant problems in wanting to retrofit a recycled water main into an industrial zone once all of the other services and roads have been built. The ability to provide 't-junctions' and to locate storage tanks near possible stormwater harvesting sites will allow for modifications to the supply system into the future at minimum cost.

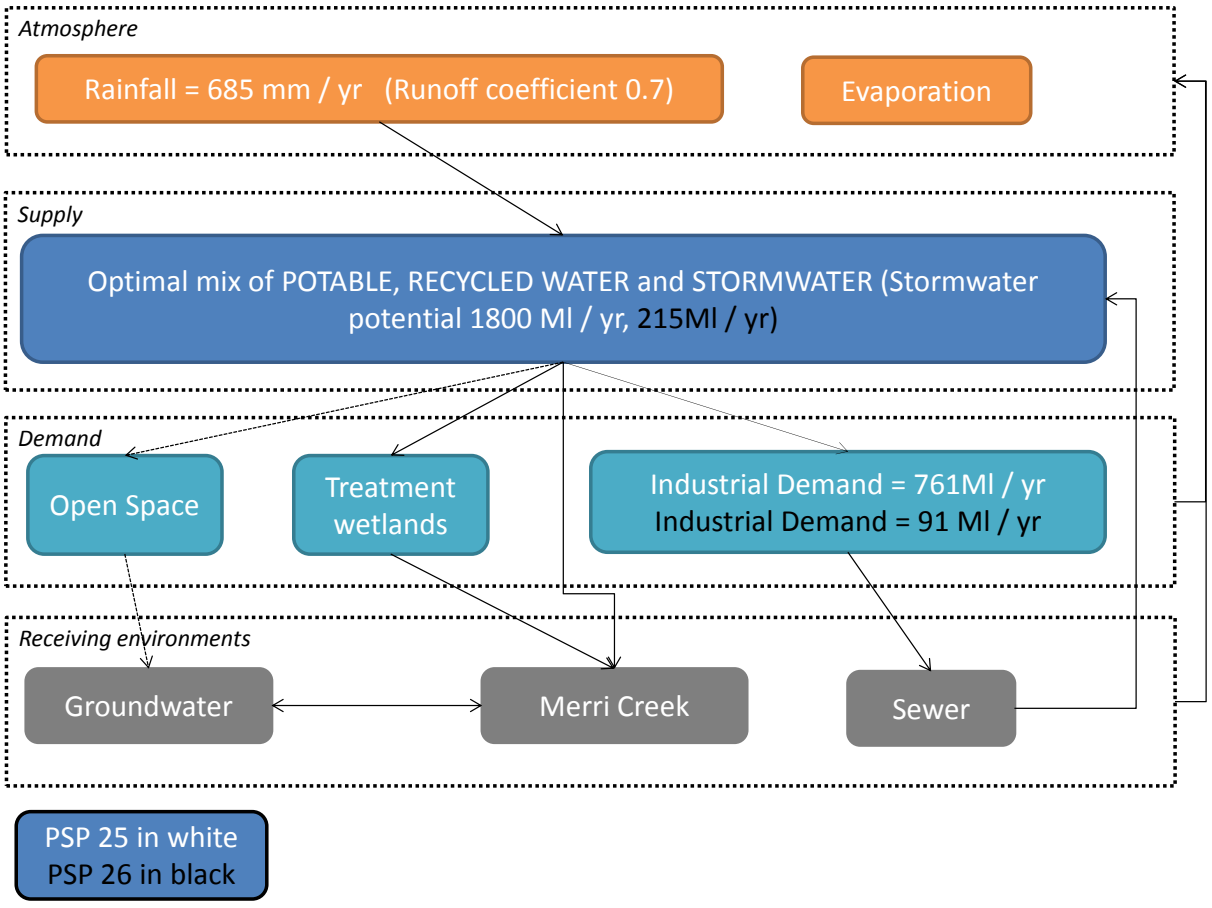

Figure 23. *Conceptual supply and demand strategy for PSP 25 and 26*

5.5 Recommendations and considerations

While there is uncertainty in the final demand for water in this region, it is estimated that almost 800 megalitres a year of various water sources is required to meet a typical industrial demand. The recommendation for this study is that the principles of flexibility and resilience be adopted in the approach to supply of water sources to meet this demand.

In choosing the right types and volumes of supply, it is recommended that a combination of stormwater, recycled water and potable water be considered. There is a large opportunity for these PSPs to demonstrate in an industrial zoned region, to manage a range of supply options to produce multiple benefits. This site could become a demonstration site in greater Melbourne in terms of its approach to managing multiple water sources, and matching appropriate demands to supply.

Finally, there is an opportunity to consider how to add value to the stormwater quality wetlands that are proposed to treat some of the stormwater pollutant generated from the study area, and introduce a stormwater harvesting component to these assets. A detailed study on the sizing, quality, cost and location of stormwater harvesting adjacent to wetlands should be considered. Careful planning is required, to ensure the sustainable management of this valuable resource. Some of the potential issues associated with stormwater harvesting include its reliability of supply, cost-effectiveness, treatment requirements, impact to downstream waterway health and risks (e.g. to public, ecosystem health).

6 Conclusion

Integrated Water Management objectives
The GAA is in a position to implement a best practice sustainable urban water management system in PSP 25 and PSP 26 that will:

- Manage the quantity and quality of stormwater run-off to protect and enhance the receiving waterways.
- Integrate the stormwater management needs with the habitat requirements for the Growling Grass Frog.
- Minimise the use of potable water within the development.
- Promote the conservation, reuse and recycling of water by providing alternate water supplies in the development.
- Mitigate against flood risk and damage.
- Become a demonstration project for innovation in industrial development precincts.

Recommendations

River Health

- The buffer required for the Growling Grass frog habitat provides the opportunity to establish a healthy and vegetated riparian zone that will conserve and enhance the creek corridor. There is also an opportunity to engage the community by integrating recreational infrastructure such as cycle and walking paths, rest areas and viewing platforms. Furthermore, by locating the stormwater treatment within the Merri Creek corridor, the community will also be able to use these treatments for recreational spaces.
- There is an opportunity to gain greater environmental outcomes for the waterways by extending past the traditional flow management targets. The Integrated Management Strategy should consider the retention of more frequent flows. The drainage strategy has catered for the effect of development on the larger, less frequently occurring flows. It is recommended that the drainage strategy incorporate distributed bio-retention systems throughout the development to retain the lower, more frequent flows and protect the receiving waterways.

Stormwater Quantity

- A preliminary investigation undertaken by Alluivum has identified that the benefit of retarding basins is questionable and may potentially have an adverse effect on the timing of the peak flows. It is recommended that a detailed overall catchment model be prepared to confirm this preliminary finding. *(As of October 2012 Melbourne Water has commissioned a study to rebuild the Merri Creek hydrologic model to accurately assess the impact of local development on the overall Merri Creek system. It is recommended that the updated Merri Creek hydrologic modelling be used to confirm that retarding basins would not be appropriate in the PSP area.)*
- If the outcome of the above study confirms that retarding basins are not necessary, our recommendation is that the railway culvert crossings are upgraded. The benefit of this option is reduced land take and it is likely to be a more economic option. Furthermore, it is possible that the invert of the railway crossings will need to be lowered to provide a free drainage outfall for future development.
- If there proves to be a need for retarding basins, it is recommended that they are integrated with open space as to provide a multitude of benefits, including amenity, social and water quality.
- It is recommended four drainage reserves of 40m width are included in the road network design in the proposed locations.

Stormwater Quality

- Although it is not mandated in industrial developments, there is also an opportunity to create a more distributed stormwater treatment system throughout the development. It is recommended that this approach is taken to decrease the risk of failure of the stormwater treatment system, protect the waterways and enhance the streetscape amenity.

- There exists an opportunity to integrate the stormwater treatment and the source of water for the Growling Grass frog ponds. It is recommended that the Growling Grass frog ponds (constructed wetlands) be watered with treated stormwater, marrying the ecological requirements and the integrated water management. This recommendation should be further explored in the preparation of the Growling Grass Frog Conservation Management Plan.

- There also exists an opportunity to incorporate WSUD treatments into the open space that is required for setbacks from the transmission line. This would provide an opportunity to improve the quality of the stormwater entering the Merri Creek in the northern area of the PSP, improve the aesthetic of the area and also utilise the otherwise ineffective open space.

Fit For Purpose Water Sources

- The use of the potable water supply should be minimised by providing alternate water sources, such as recycled water and stormwater harvesting and reuse (such as rainwater tanks).

- Yarra Valley Water have indicated that while this area is not a mandated recycled water area, a recycled main runs along Brookfield drive through the PSP 25 and there is potential to supply industrial developments. There is the opportunity to mandate the use of recycled water within the PSP area in an integrated water management strategy. There are several (residential) regions outside of the study area that are mandated recycled water areas, and it is recommended that the same is done within PSP 25 and PSP 26.

- This site should be considered as a demonstration site for the use of alternative water supplies for industrial use. An optimal mix (optimal in the sense of maximising the use of recycled and stormwater supplies and the minimising of cost) of water sources could be incorporated and done so at the beginning of the development to minimise costs.

7 References

BMT WMB (2011), Kalkallo Creek Development Services Scheme. A report prepared for Melbourne Water.

CPG Australia (2012), Rockbank North PSP. Final report prepared for the Growth Areas Authority.

Department of Sustainability and Environment (2011) , Sub-regional Species Strategy for the Growling Grass Frog (Draft).

Ecology & Heritage Partners (2011), Rockbank North Precinct Structure Plan: Conservation Management Plan for the Growling Grass Frog, *Litoria rainformis*. Final report prepared for the Growth Areas Authority.

Growth Areas Authority (2011), 2011 Draft Growth Corridor Plan.

Melbourne Water (2008.) Port Phillip and Westernport Regional River Health Strategy (2008-2013).

Melbourne Water (2009), Merri Creek: Development of Land Subject to Inundation Overlay.

Melbourne Water (2012), Donnybrook Developer Services Scheme.

Yarra Valley Water (2012), Kalkallo- Wallan South Recycled Water Infrastructure Plan.