Lindum Vale Precinct Structure Plan Amendment C205 to the Hume Planning Scheme

Expert Witness Report

Final

12 February 2018

Report by: Valerie Mag, B.E. Civil (Hons), M. Eng. Sci.

Stormy Water Solutions

stormywater@optusnet.com.au

M 0412 436 021

Contents

1. Statement of Evidence

I have been retained to prepare an expert witness report within the scope of my expertise and present evidence at the panel hearing to express my opinion as to whether Amendment C205 is appropriate having regard to:

a) Any regulatory framework application to the proposal which is within my expertise to examine and comment on;
b) My own judgement and expertise; and
c) Any other matter which I regard as relevant to the formulation of my opinion, stating the basis clearly in my views.

All matters raised by "Planning Panels Victoria, Guide to Expert Evidence" are detailed in Appendix A of this expert witness report.

In May 2015, Hume City Council requested that I review drainage proposals for the development of Lindum Vale proposed by Dalton Consulting Engineers Pty Ltd (DCE), MAB Corporation Pty Ltd and GPC Pty Ltd. Specifically, I was to assess if the drainage strategy proposed at that time would minimise ongoing risks to the existing river red gums on site. Subsequently, I prepared a report titled "Lindum Vale, Mickleham, Independent Hydrological Assessment, 21 May 2015 (**May 2015 Hydrological Assessment**).

I adopt the May 2015 Hydrological Assessment (**Addendum 1**) in combination with this document, as my Expert Witness Report for the purposes of the Planning Panels hearing in relation to amendment C205 to the Hume Planning Scheme commencing on the 19 February 2018.

My conclusions detailed in the relation to the May 2015 Hydrological Assessment (**Addendum 1**) have not changed in this Expert Witness Report.

However, since May 2015 the drainage proposals for the site have changed somewhat. The latest drainage strategy is detailed in an Alluvium report entitled "Surface Water Management Strategy, 1960 and 2040 Mickleham Road, Mickleham, Lindum, Vale, December 2017" (referred to as the **Alluvium 2017 Drainage Strategy** in this report).

In addition, the "green link" proposals for the site have changed since May 2015. The "green link" refers to areas defined as "conservation reserve", "local park", and "landscape values" areas on Plan 3- Future Urban structure, Lindum Precinct structure Plan 16 January 2018 (referred to as **Plan 3** in this report.

My opinions in regard to the current Alluvium 2017 Drainage Strategy proposals are summarised in Section 3 below.

I conclude that Amendment C205 (Plan 3) is appropriate having regard to allowing enough reserve space (green link areas) to ensure the future adoption of various methods to capture stormwater runoff for the use of watering the existing river red gums on site while also ensuring both minor and major surface flows can be conveyed though the site.

However, the potential for stormwater capture may be limited as the “Revised Plan 3 – Future Urban Structure” wording, although capturing the space required for tree retention under “tree protection zones”, does not describe the potential preferred mechanisms for watering the trees with stormwater via the implementation of a suitable Stormwater Management Strategy.

The current Alluvium 2017 Drainage Strategy does refer to possible ways drainage infrastructure could be integrated with the landscape to passively water trees. However, the strategy will not ensure this will occur. The current strategy advocates traditional 18.13% Annual Exceedance Probability (AEP) pipelines and 1% AEP overland flow paths.

As detailed in Section 3, I have suggested an alternative drainage strategy. I consider that adoption of an alternative drainage strategy in line with my suggestions would allow stormwater runoff to be available for passive watering of almost all the trees retained in reserves/green link areas. Once stormwater feeds can be assured, the only design considerations going forward would be individual assessment of each tree (or group of trees) and appropriate throttling of bubble up pit mechanisms etc., to ensure optimal watering.

Essentially, the suggested alternative drainage strategy could ensure stormwater water can be supplied to trees in the future. The current Alluvium 2017 Drainage Strategy runs the risk of adoption of traditional pit and pipe mechanisms, which would result in little or no future opportunity to adopt a large scale passive watering strategy for the trees.

To ensure the future opportunity for stormwater harvesting for passive irrigation is not lost (or minimised), the adopted stormwater management strategy must (at the very least) propose an alternative drainage design advocating specific concept designs of the following:

- The road, drainage and subdivision catchment delineation,
- Pipe alignments and rough sizing,
- Bubble up pit proposals,
- Swale designs (preliminary sizing and alignments in and around the trees), and
- Any potential reduction in the outfall wetland and retarding basins sizes via the implementation of an upstream swale system.

I recommend that, prior to the Alluvium 2017 Drainage Strategy becoming a background document to the PSP, it be updated to advocate as a viable alternative to the existing drainage proposals, a strategy similar to the alternative drainage strategy detailed in this expert witness report.

Alternatively, at the very least, the following three reports should be included as background documents to the PSP:

- The Alluvium 2017 Drainage Strategy,
- The Stormy Water Solutions May 2015 Hydrological assessment (Addendum 1 of this report), and
- This February 2018 Stormy Water Solution Expert Witness Report.

As discussed in Section 3.4 below, I would suggest that the updated wording in G36 will not ensure enough water to passively irrigate all trees within the green link areas going forward. I consider that this should be revised further to provide greater certainty that passive irrigation is provided at planning permit stage.

2. Summary of Opinions

A summary of my opinions as of May 2015 is contained in Section 5 of the May 2015 Hydrological Assessment (**Addendum 1**).

3. Further Considerations since Preparation of the May 2015 Hydrological Report

I have not materially changed my opinions or conclusions detailed in the May 2015 Hydrological Assessment (**Addendum 1**).

However, since May 2015 the drainage proposals for the site have changed somewhat. The latest drainage strategy is detailed in an Alluvium report entitled "Surface Water Management Strategy, 1960 and 2040 Mickleham Road, Mickleham, Lindum, Vale, December 2017" (referred to as the **Alluvium 2017 Drainage Strategy** in this report).

In addition, the "green link" proposals for the site have changed since May 2015. The "green link" refers to areas defined as "conservation reserve", "local park", and "landscape values" areas on Plan 3- Future Urban structure, Lindum Precinct structure Plan 16 January 2018 (referred to as **Plan 3** in this report.

Given the above, I have revised my "Possible Alternative Drainage Strategy" (Figure 1 in Addendum 1) to Figure 1 below. I have then assessed this revised plan against the usual drainage requirements and regulatory frameworks applicable to developments of this type.

3.1 Possible Alternative Drainage Strategy (2018)

A suggested alternative drainage strategy (to that currently proposed by Alluvium) is detailed in Figure 1 below.

The primary characteristics of this strategy are:

- To, as far as possible, design small swales to meander in and around existing trees to allow passive watering via stormwater runoff,
- To keep catchments and pipes as small and shallow as possible to facilitate easy implementation of the bubble up and low flow bypass system as per Figure 2, Addendum 1,
- To direct the proposed low flow outlets (which should be small and shallow) from the northern and southern wetlands to the green links for bubble up into the swale systems,
- To feed the green link connection at Mickleham Road (Point B, Figure 1) with flow entering from a small road culvert at this point,
- To allow a traditional pipe and overland flow provisions from the main Mickleham Road entry (Point A, Figure 1) to the green link at Point C.

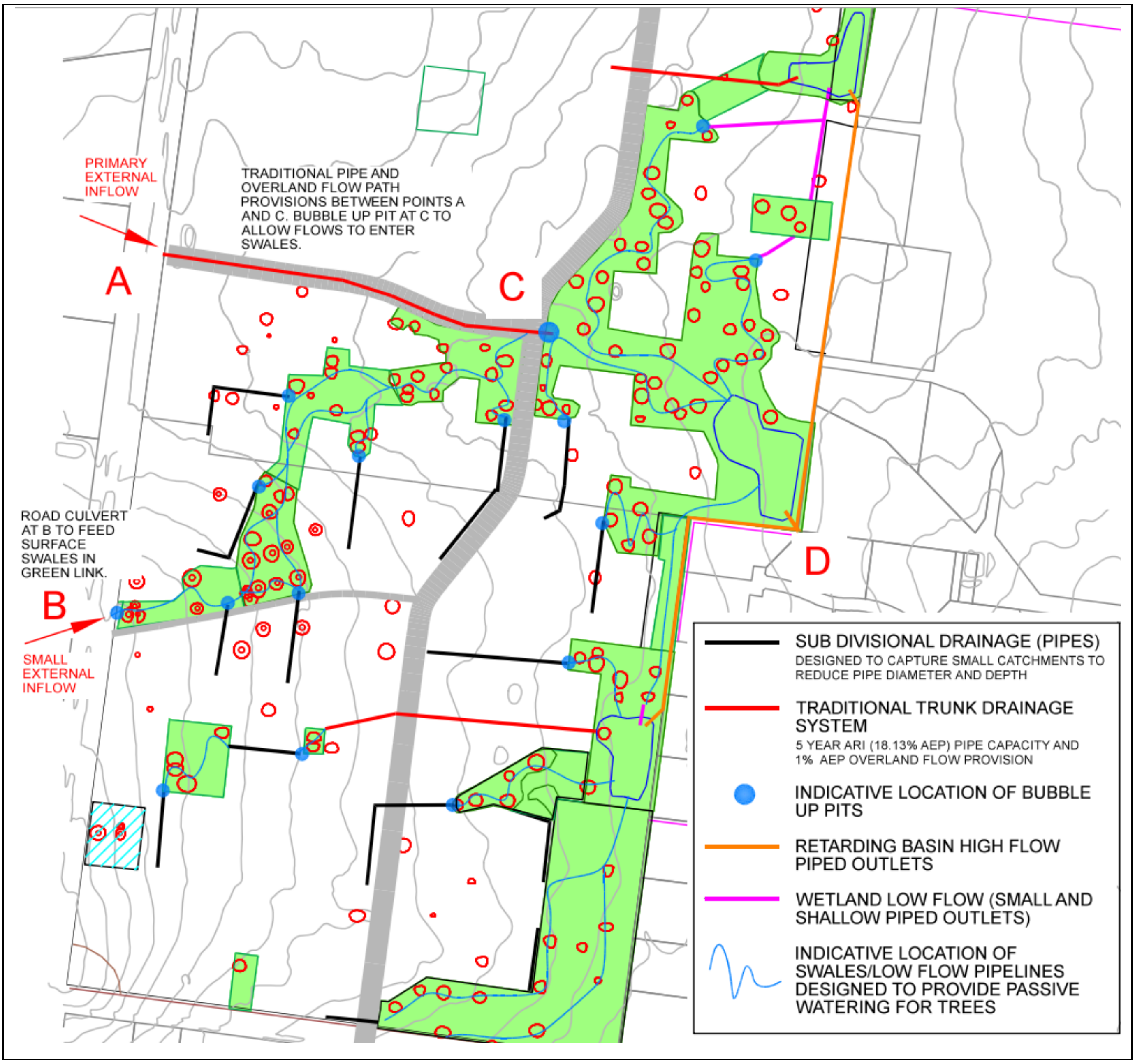


Figure 1 **Possible Alternative Drainage Strategy (2018)**

As detailed in Figure 1, the alternative drainage strategy has the potential to passively water a significant amount of the existing trees on site. Figures 2 and 3 below provide examples of how, in a landscape sense a bubble up pit and swale could be incorporated into the green link areas. It should be noted, that as shown, systems if this type are currently being used all over Melbourne. The difference would be that instead of an 18.13% AEP underlying pipe, the underlying bypass pipe would be small enough to ensure regular bubble up of stormwater and watering of trees.

Figure 2 **Example of how a bubble up pit and swale could be incorporated into the green link (Glen Waverley).**

Figure 3 **Example of Swale Integration with Trees (Roxburgh Park)**

There will be some trees located outside of the green link areas. To protect these trees individual sites should be assessed to determine other passive watering opportunities such as providing:

- Direct passive watering of trees from hard stand areas,
- Providing offsets to trees in road reserves and lots,
- Providing tree protection zones and maximising impervious areas around trees in lots (possibly though a 173 agreement of individual lots), and
- Allowing for direct roof runoff to tree protection zones on lots.

An example of a successful lot scale development incorporating these initiatives is the KLM Spatial Pty Ltd office complex in Dandenong. This development (construction 2015/2016) has successfully retained and is passively watering about 5 river red gums on site. Feedback from KLM Spatial indicates that, although due consideration of site drainage issues was required during the design and construction process, the retention of the trees has been very successful both in a landscape and business sense. Figure 4 details two of the trees within tree protection zones on the KLM Spatial site.

Figure 4 Example of Site scale passive Watering of Trees (Dandenong South).

3.2 Implementation Issues

3.2.1 Drainage System Design

The alternative drainage strategy detailed in Figure 1 relies on a fundamental principal of allowing stormwater to passively water the trees on site. It is proposed to use the subdivisional drainage system to facilitate passive tree watering via the bubble up pits arrangement as detailed in Figure 2 in Addendum 1. This can be done via:

- Minimising contributing catchment area to minimise pipe sizes,
- Minimising pipe cover (600 mm max to natural surface level), and
- Using the above two design principals to keep the piped drainage system invert levels as shallow as possible.

An appropriate hydrological model (to current Australian Rainfall and Runoff 2016 (**ARR 2016**) requirements) will be required to be developed to adequately delineate these small sub catchments and the swale distribution system. Preliminary 2015 investigations detailed in Addendum 1 suggest that most subdivisional pipelines would be 450 – 600 mm diameter at their outfalls to the reserve in the alternative drainage strategy. 18.13 % AEP Hydraulic Grade Line (HGL) analysis of all subdivisional pipelines will be required during the design process (given a tail water level at just above the natural surface in the reserve at each outlet).

A benefit of the alternative drainage strategy is that, even in very large flow events, the flood waters are now allowed to move very slowly through the subdivision. This "slowing down" of the flow complements the natural storage effect of the catchment, providing an effect not unlike the provision of a retarding basin. This can result in a reduction in the retarding basin provisions required downstream at the outlets. This is discussed in Section 7 of Addendum 1.

3.2.2 Flood Protection

If the alternative drainage strategy is adopted, hydrological models as recommended by ARR 2016 should be used to determine 1% AEP flood flows within all green link areas. A model such as TuFlow should then be applied to assess:

- Flood depths, velocities and flood levels in the green link areas, and
- Required fill levels adjacent to the reserves.

As per Section 10 in Addendum 1, preliminary calculations suggest 1% AEP flood levels should be at or about natural surface level at the edge of the greeen link areas. As such, it is expected that the resulting in lot levels being required should be in the order of 600 mm (or the freebourd provision required by Melbourne Water and/or Council) above the adjacent green link reserve boundary level.

Access paths within the green link areas will probably be required to be set at least at the 10% AEP flood level. Slightly elevated boardwalk systems over and through the grassland areas could control people movement though some parts of the green link areas (as required).

3.2.3 Stormwater Pollution Retention on Site

The development will be required to show stormwater pollutant retention to current best practice being 80% retention of Total Suspended Solids (TSS), 45% retention of Total Phosphorus (TP) and 45% retention of Total Nitrogen (TN) on site.

Facilitating both low flow and high flow at surface in the reserves allows stormwater pollutant treatment to occur as the stormwater flows over the grassed surface. In MUSIC this can be modelled as “swale” treatment. The width of the sheet flow can be significant resulting very good stormwater pollutant removal given the very simplistic nature of this mechanism. The obvious benefit is a resultant optimisation in the wetland system area required at the site outfall points.

Melbourne Water do not usually attribute any stormwater treatment to flow in drainage reserves. This is because waterways in reserves are designed as vegetated channels. Vegetated channels are generally treated as “receiving bodies” rather than treatment elements. However, this system is not a “vegetated channel”. It is sheet flow over an extensive grassed surface. If not modelled as a “swale” the resultant increase in downstream sediment pond and wetland area could result in loss of River Red Gums due to the sediment pond/wetland construction. It would be a shame if trees were lost due to a model not accounting for what will actually physically happen.

3.2.4 Drainage System Cost

The “engineering” suggested for the proposed alternative drainage strategy is not complex. The major barrier to implementation of a scheme such as this is that it is different from how the industry currently applies drainage provisions within a site, and therefore requires a slight shift in project approach and application in all the professionals and organisations involved.

It is suggested that, even if it is a desk top exercise, that the cost of implementation of a traditional drainage strategy (such as that currently proposed by Alluvium) be compared to the cost of implementation of the alternative drainage strategy advocated within this report.

The benefits of the suggested alternative drainage strategy, in terms of cost reductions, should be:

- Reduced construction costs due to :
  - The lengths and sizes of the concrete pipes being decreased, and
  - The distributed nature of the swales leading to smaller wetland and retarding basin storage volumes and site area requirements,
- Reduced ongoing maintenance costs due to the “self watering” nature of the strategy, which should significantly reduce artificial tree watering costs, especially during dry periods.

The primary additional developer cost associated with the alternative drainage strategy is expected to be a more expensive design and planning process. This may occur due to the site specific nature of the swale designs in the green link areas and the investigations (hydrological and ecological) required to ensure enough background technical knowledge is obtained to ensure appropriate throttling of the low flow bypass pipes.

3.2.5 Watering Requirements of Individual Trees and Groups of Trees

Allowing all flow from the development to the reserve surface may result in overwatering of the trees (in some cases). As such, the low flow bypass pipeline (and possibly the infiltration screening mechanism) should be designed to bypass a small amount of flow and allow surface flow to the treed areas at a rate/annual volume which mimics the existing situation (or the suggested optimal watering regime). This analysis would be based on an expert ecological advice for individual trees (or groups of trees) and a daily water balance.

Obviously, detailed analysis of each tree on site is not required at this planning stage. What is required is the adoption of a drainage strategy which ensures that there is surface water available for passive watering of trees well into the future. Feed rates can be set at a later late. With a strategy ensuring stormwater will be available, the only design considerations going forward would be individual assessment of each tree (or group of trees) and appropriate throttling of bubble up pit mechanisms etc., to ensure optimal watering.

3.2.6 System Maintenance and Ownership

In facilitating surface flows, there may be significant areas which are relatively “wet” in the reserve over the course of a year. This obviously hampers mowing activities and reserve access.

Rather than a design constraint, this should be seen as an opportunity to encourage establishment of native grasslands etc. The final “look” of the reserve could be very similar to what would have been observed 200 years. That is, river red gum stands within native grass (and other appropriate vegetation).

Notwithstanding the above, the primate maintenance activities are expected to be:

- Sediment cleanout from sump systems at bubble up pit inlets,
- Mowing,
- Vegetation/bushland management, and
- Ensuring low flow pipeline is clear and operational.

For the most part, the size of the catchment to green link areas will result in the above maintenance activities (and asset “ownership”) falling under Council’s jurisdiction.

Historically, the drainage system between of Points A, C and D (Figure 1) would be the responsibility of Melbourne Water. This is because the catchment is greater than 60 ha at Point A. In the December 2017 VPA meeting it was noted that this alternative strategy is not defining a waterway downstream of Point C, it is defining a flood plain. Melbourne Water indicated in the December 2017 VPA meeting that downstream of Point C some sort of primary flow path would be required to be defined to delineate Melbourne Water's/Council responsibility within the green link area. Council also indicated at this meeting that they would be conducive to maintain the total extent of the naturalistic flow path in the Green Link areas.

Whatever the case, a formal agreement will be required to ensure clear delineation of maintenance and ownership responsibilities within the Green Link areas going forward.

3.3 Review of Alluvium 2017 Drainage Strategy

As part of this expert witness report I have conducted a high level review of the Alluvium 2017 Drainage Strategy.

The general strategy approach taken by Alluvium is considered to be appropriate for a "traditional" application of a drainage strategy to a Greenfield Site. That is, subdivisional 18.13 % AEP pipes will outfall to three wetland/retarding basin sites where stormwater treatment/retardation will occur.

My review indicates that the area allocated for the wetlands/retarding basins appears reasonable.

However, the strategy does not appear to define the road culvert connection required at Point B, Figure 1.

In addition, Alluvium has not used current best practice hydrological modelling approaches in the drainage strategy as suggested in ARR 2016. The predevelopment flows have been determined using the Adams Rural Rational Method. This method is no longer advocated as suitable for undeveloped catchments in ARR 2016. Post development flows have been calculated using the RORB Runoff Routing program. This program is advocated as suitable for this application in ARR 2016. However, Alluvium have not used applicable 2016 Bureau of Metrology rainfall intensity data or ensemble temporal pattern considerations as currently advocated in ARR2016.

I consider that, as ARR 2016 has been published for the last 18 months, drainage strategies developed in late 2017 should incorporate its approaches and requirements. This is particularly important in retarding basin design where the 2016 methods utilising "more realistic" rainfall patterns are making a difference to retarding basin storage characteristics.

Further, Melbourne Water is currently advocating a requirement to adopt 'residential' type source nodes in the MUSIC model. It is assumed that the Alluvium wetlands were sized using "mixed" nodes. Melbourne Water has recently indicated to me that "mixed" nodes less accurately estimates the actual pollutant loads flowing off a developed catchment according to the most recent research. The outcome of this change is that wetland sizes required (as calculated by the MUSIC model) are larger than previously required.

Given the above, it is suggested that the most recent applications to the hydrological modelling as currently advocated by ARR 2016 and Melbourne Water be applied in any future revision to the drainage strategy or drainage design development for this site.

In summary, the reserve allocations for the drainage infrastructure appear reasonable, but this should be proven to current best practice standards.

3.4 Assessment of Amendment C205, Plan 3

Figure 1 indicates that, provided due consideration is given to the drainage design as detailed above, Amendment C205, Plan 3, Future Urban Structure (16/1/18) allows enough reserve space to allow this alternative drainage strategy to be adopted.

However, the "Revised Plan 3 – Future Urban Structure" wording may limit the potential for future stormwater harvesting. The document entitled "Revised Plan 3 – Future Urban Structure, Victorian Planning Authority, 16 January 2018" does capture the space required for tree retention under "tree protection zones". However there is no description of potential and/or preferred mechanisms for watering the trees with stormwater via the implementation of a suitable Stormwater Management Strategy.

The current Alluvium 2017 Drainage Strategy does refer to some possible ways drainage infrastructure could be integrated with the landscape to passively water trees. However, the drainage strategy advocated by Alluvium does not facilitate automatic availability of subdivisional stormwater to the green link areas.

The current strategy advocates traditional 18.13% AEP (1 in 5 year ARI) pipelines and 1% AEP overland flow paths.

As detailed in Figure 1, I consider that with due drainage design considerations, almost all the trees restrained in reserves could be passively watered via a bubble up arrangement at outfall points to the green link areas.

If the alternative strategy as per Figure 1 (or simular) were adopted, then the only design considerations going forward would be individual assessment of each tree (or group of trees) and appropriate throttling of bubble up pit mechanisms etc., to ensure optimal watering.

Essentially, the suggested alternative strategy will ensure stormwater water can be supplied to trees in the future. The current Alluvium 2017 Drainage Strategy runs the risk of adoption of traditional pit and pipe mechanisms, which would result in little or no future opportunity to adopt a large scale passive watering strategy for the trees.

To ensure the future opportunity for stormwater harvesting for passive irrigation is not lost (or minimised), the adopted stormwater management strategy must (at the very least) propose an alternative drainage design advocating for consideration the following:

- The road, drainage and subdivision catchment delineation,
- Pipe alignments and rough sizing, and
- Bubble up pit proposals,
- Swale designs (preliminary sizing and alignments in and around the trees), and
- Any potential reduction in the outfall wetland and retarding basins systems via the implementation of an upstream swale system.

VPA Part A response to the Hume City Council Submission provided to Stormy Water Solutions on 5 February 2018 proposes the following.

- R30 will be updated to: The design and construction of drainage infrastructure must include measures to protect and enhance the long term viability of vegetation, particularly the River Red Gums, through the use of Water Sensitive Urban Design and passive watering initiatives. This design must be based on a vegetation survey and assessment undertaken in conjunction with Council
- G36 will be converted to a requirement and updated to: "Development must reduce reliance on reticulated non potable water for irrigation of vegetation, including existing mature River Red Gums, through utilisation of passive irrigation facilitated by appropriate subdivision and road design, where practical."

In line with my comments above:

- I support the update to requirement R30, and
- I support converting G36 to a requirement.

However, I would suggest that the updated wording in G36 will not ensure enough water to passively irrigate all trees within the green link areas going forward. I consider that this should be revised further to provide greater certainty that passive irrigation is provided at planning permit stage.

3.5 Conclusions

The 2013 analysis (Addendum 1) was a desk top exercise designed to show that passive watering of the existing river red gums on site can occur within the subject site. This expert witness report further expands on this 2015 work given the January 2018 VPA Plan 3 the Alluvium 2017 Drainage Strategy.

I consider that, with due drainage design, Amendment C205, Plan 3, Future Urban Structure (16/1/18) allows enough reserve space to allow large scale passive watering of the existing river red gums on site.

However, adoption of the “Revised Plan 3 – Future Urban Structure, Victorian Planning Authority (16 January 2018), the “VPA Part A response to the Hume City Council Submission (5 February 2018)” and the Alluvium 2017 Drainage Strategy run the risk of adoption of traditional pit and pipe mechanisms, which would result in little or no future opportunity to adopt a large scale passive watering strategy for the trees.

To achieve the ecological and hydrological benefits detailed in this report all of the engineering recommendations discussed are required to be adhered to. In particular subdivision catchments, pipe sizes and pipe depths must be minimised.

This aspect of the design requires diligent and specific consideration of the road, drainage and subdivision catchment delineation and pipe alignments at an early stage in the design process. The methodology advocated within this report and Addendum 1 is required to be adhered to during ALL stages of the design and construction process.

The “engineering” suggested in this report is not complex. The major barrier to implementation of a scheme such as this is that it is different from how the industry currently applies drainage provisions within a site, and therefore requires a slight shift in project approach and application in all the professionals and organisations involved.

In conclusion, at this stage I consider that the Alluvium 2017 Drainage Strategy is not yet in an appropriate form for inclusion as a background document to the PSP.

4. Recommendations

I recommend that, prior to the Alluvium 2017 Drainage Strategy becoming a background document to the PSP, it be updated to advocate as a viable alternative to the existing drainage proposals, a strategy similar to the alternative drainage strategy detailed in this expert witness report.

Alternatively, at the very least, the following three reports should be included as background documents to the PSP:

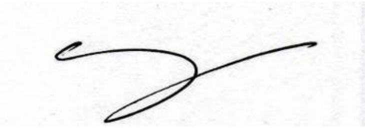
- The Alluvium 2017 Drainage Strategy,
- The Stormy Water Solutions May 2015 Hydrological assessment (Addendum 1 of this report), and
- This February 2018 Stormy Water Solution Expert Witness Report.

As discussed in Section 3.4, I would suggest that the updated wording in G36 will not ensure enough water to passively irrigate all trees within the green link areas going forward. I consider that this should be revised further to provide greater certainty that passive irrigation is provided at planning permit stage.

5. Declaration

I acknowledge that I have read the Expert Witness Code of Conduct and agree to be bound by it.

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the panel.



Valerie – Joy S Mag
B.E. Civil (Hons), M. Eng. Sci.
Principal
STORMY WATER SOLUTIONS
1.26 202 Jells Road
Wheelers Hill 3150
February 2018

Appendix A Matters Raised by Planning Panels Victoria, Guide to Expert Evidence

1. The name and address of the expert.

Valerie – Joy S Mag
B.E. Civil (Hons), M. Eng. Sci.
Principal
STORMY WATER SOLUTIONS
1.26 202 Jells Road
Wheelers Hill 3150

2. The expert's qualifications and experience.

For qualifications and experience refer to Appendix B of this report.

3. Expert's area of expertise.

I am a hydrologist with 28 years' experience in hydrology and hydraulics and various applications of these fields. My educational qualifications are as follows:

- Bachelor of Civil Engineering, Monash University (1989)
- Master of Engineering Science (Water Resources and Environmental Engineering), Monash University (1993)

I have twenty eight years' experience and expertise in hydrologic and hydraulic engineering, particularly in the areas of:

- Preparing complex urban and rural flood plain strategies,
- Preparing Water Sensitive Urban Design Strategies,
- Major catchment analysis, including flood flow and flood level estimation,
- Planning and assessment of development within flood plain and overland flow path systems,
- Reviewing drainage strategies prepared by other consultants for Melbourne Water and various councils, and
- Regularly preparing and conducting training in drainage and WSUD for the Municipal Association of Victoria, Vic Roads, Melbourne Water, the Department of Tourism Arts and the Environment (Tasmania), ARRB Group and others.

My CV is attached as Appendix B.

4. Expert's expertise to make the report.

I have been involved in various drainage projects with in Melbourne Water Aitken Creek Development Services Scheme (into which catchment this development falls) over almost all of my 28 year career, firstly during my time at Melbourne Water and lately in my role as a consultant engineer. Apart from the May 2015 Hydrological Assessment work completed for Council, I have not been involved in the drainage strategy development for the subject site.

5. Reference to any private or business relationship between the expert witness and the party for whom the report was prepared.

Since the inception of Stormy Water Solutions in 2003 I have been retained by Hume City Council to undertake various hydrological investigations including an audit of all Hume City Council Water Sensitive Urban Design assets in 2015 and various smaller projects (which have included retarding basin and wetland designs and reviews).

6. All instructions that define the scope of the report.

In May 2015, Hume City Council requested that I review drainage proposals for the development of Lindum Vale proposed by Dalton Consulting Engineers Pty Ltd (DCE), MAB Corporation Pty Ltd and GPC Pty Ltd. Specifically, I was to assess, in my opinion, if the drainage strategy proposed at that time would minimise ongoing risks to the river Red gums on site.

Subsequently, I prepared a report titled “Lindum Vale, Mickleham, Independent Hydrological Assessment, 21 May 2015 (**May 2015 Hydrological Assessment**).

In a letter dated 15 December 2017, King and Wood Mallesons requested that I prepare an expert witness report within the scope of my expertise and present evidence at the panel hearing to express my opinion as to whether Amendment C205 is appropriate having regard to:

a) Any regulatory framework application to the proposal which is within my expertise to examine and comment on;
b) My own judgement and expertise; and
c) Any other matter which I regard as relevant to the formulation of my opinion, stating the basin clearly in my views.

7. The facts, matters and all assumptions upon which the report proceeds.

Refer to the May 2015 Hydrological Assessment (**Addendum 1**) and Section 3 of the Statement of Expert Evidence.

I have assumed that all submissions relevant to my area of expertise have been provided to me.

8. Documents and other materials the expert has been instructed to consider or take into account in preparing her report and the literature or other material used in making the report.

I have reviewed the following material in regard to the preparation of this statement of expert evidence:

1. Surface Water Management Strategy, 1960 and 2040 Mickleham Road, Mickleham, Lindum Vale, Alluvium, December 2017 **(Alluvium 2017 Drainage Strategy)** ,
2. A document entitled "Revised Plan 3 – Future Urban Structure, Victorian Planning Authority, 16 January 2018
3. A plan entitled "Plan 3 – Future Urban structure, Lindum Vale Precinct Structure Plan, Draft for Discussion, Victorian Planning Authority, 16 January 2018,
4. Lindum Vale PSP, Summary Land Use Budget, 16 January 2018,
5. VPA Part A response to the Hume City Council Submission provided to Stormy Water Solutions on 5 February 2018, and
6. Planning Panels Victoria, Guide to Expert evidence

My report is also based on:

- "Lindum Vale, Mickleham, Independent Hydrological Assessment, 21 May 2015, Stormy Water Solutions (**May 2015 Hydrological Assessment,** attached as **Addendum 1** of this report).
- A meeting held at Victorian Planning Authority (**VPA**) on 11 December 2018 in which Council, the Victorian Planning authority, Melbourne Water, Slattery Property Group and various consultants were present and the meeting minutes prepared by VPA,
- A site visit conducted in the 5 February 2018,
- An email from Rudyard Lindley of KLM Spatial received by me on 1 February 2018 detailing photos and his experience of protecting river red gums on his new office site in Dandenong
- My knowledge of the catchment through the many projects I have been involved with, both in my time at Melbourne Water and in consultancy.
- Ball J, Babister M, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (ARR 2016)

9. The identity of the person who carried out any tests or experiments upon which the expert relied in making the report and the qualifications of that person.

The May 2015 Hydrological Assessment (**Addendum 1**) and this Expert Witness Report rely on investigations and hydrological calculations carried out by myself only.

10. A summary of the opinion or opinions of the expert.

For the summary of opinion refer to Sections 3 and 4 of the Statement of Expert Evidence.

11. Provisional opinions that are not fully researched for any reason (identifying the reason why such opinions have not been or cannot be fully researched).

I do not consider that the May 2015 Hydrological Assessment (**Addendum 1**) or this Expert Witness Report is incomplete or inaccurate in any respect. However, the flood hydrology (estimate of flood flows) has not been updated at this stage to reflect current changes in Australian Rainfall and Runoff 2016. Flood flows and models are as have been previously modelled in 2015 by myself. Notwithstanding the above, in other projects conducted in Melbourne during 2017, flood flows have not varied significantly between ARR 1987 and ARR 2016 estimates.

12. Any questions falling outside the expert's expertise and whether the report is incomplete or inaccurate in any respect.

Ecological and environmental issues relating to the specific requirements (especially the specific watering requirements) of the existing river red gums on the site fall outside my area of expertise.

Appendix B Valerie Mag – Curriculum Vitae

Bachelor of Engineering (Honours) 1989, Monash University

Master of Engineering Science 1992, Monash University

Mobile: 0412 436 021

Email: stormywater@optusnet.com.au

Personal Profile

Valerie prides herself on delivering good environmental engineering solutions, on time and within budget. She is an accomplished flood hydrologic and hydraulic modeller, with many years' experience applying models such as RORB, Hec Ras and MIKE 11 to complex urban and rural flood plain strategies.

Over the past twenty three years Valerie has been involved in (and been responsible for) many urban stormwater quality management projects, both in Victoria and interstate. She has a comprehensive understanding of the issues involved in developing water sensitive urban design (WSUD) strategies, including wetland and bioretention design, and is proficient in the application of stormwater pollutant models (such as MUSIC) to these applications.

Valerie was an independent reviewer of the 2010 Melbourne Water Corporation Wetland Design Guidelines and 2011 Melbourne Water Corporation MUSIC Guidelines.

Valerie has a Master's Degree in Water Resources and Environmental Engineering. She is passionate about providing transparent and clear environmental engineering directions in her products so that all stakeholders can fully embrace the exciting potential of water sensitive urban design.

Employment History

Stormy Water Solutions - Principal	**(2003 - present)**
Ecological Engineering Pty Ltd	(2001 - 2003)
Melbourne Water Corporation	(1991 - 2001)
Dandenong Valley Authority	(1989 - 1991)
Boral Johns Perry Power Projects	(1989)

Experience

TRAINING

In early 2004 Stormy Water Solutions developed the first of many courses and workshops which it subsequently offered to various organisations and individuals to supplement their knowledge of best practice drainage and WSUD requirements and engineering techniques. Over the thirteen years since inception, Stormy Water Solutions has conducted over 90 courses and workshops and trained approximately 1800 practitioners including engineers, mangers, planners and landscape architects.

Training courses have been packaged together into one or two day training courses, or presented separately as half day to one day training modules as required. Courses have also been custom designed to fit the exact requirements of various organisations.

The modules are designed for practitioners who are involved in the planning, design and/or approval of drainage and WSUD projects. We have conducted training for Melbourne Water, the Clearwater Program, The Derwent Estuary Program (Tasmania), Vic Roads, and various councils and individual organisations.

We have trained, engineers, managers, planners, maintenance personal, landscape architects, urban designers, ecologists and environmental scientists. The courses and workshops encourage participants to discuss issues relating directly to their project experience, thus enabling all participants to learn from each other.

WATER RESOURCES MANAGEMENT STORMWATER HARVESTING

Stormwater Harvesting

Valerie has conducted many detailed water balance analysis to ensure optimal sizing of various rainwater harvesting schemes. Analysis always includes a detailed assessment of demand (e.g. irrigation, toilet flushing, washing machine etc) and supply (i.e. available catchment and rainfall etc). Analysis performed includes the concept design of major initiatives proposed for Scotch College, irrigation pond sizing in various subdivisions throughout Melbourne and many projects requiring stormwater tanks sizing including the Dandenong Markets and Springers Leisure Centre in Cheltenham.

DSE Project Assessment

Valerie was part of the small SCA Consulting Team which assess over 60 water reuse and stormwater harvesting projects for the Department of Sustainability and Environment in 2007. These projects were those funded under the 2004 Stormwater and Urban Conservation Fund. This work included assessing probable potable water savings and making recommendations in regard to which projects provided the most benefits to the Victorian community and the cost effectiveness of each project. The work provided direction to the DSE in regard to future consideration of proposed stormwater and urban recycling projects.

Stormwater Harvesting – Afton Street Stormwater Harvesting Scheme

Valerie was the concept and functional designer of the Afton Street wetland and stormwater harvesting scheme in the City of Moonee Valley. The project included the design of a sediment pond, wetland and storage dam system. In addition to the sediment pond and wetland design requirements, a detailed water balance analysis was carried out to ensure optimal sizing of the storage dam system and due consideration of placement and landscape impacts. This project received a Merit award in 2009 from Stormwater Victoria in the “Master Planning and Design” category.

WATER SENSITIVE URBAN DESIGN

Valerie was an independent reviewer of the 2010 Melbourne Water Corporation "Wetland Design Guidelines" and the 2010 Melbourne Water Corporation "MUSIC Guidelines" document.

Hume City Council WSUD Asset Audit and Rectification Project – 2015

In 2014 Optimal Stormwater and Stormy Water Solutions completed an audit of the WSUD assets within Hume City Council. The project consisted of auditing 55 projects including wetlands, bioretention systems, swales and ponds and recommending rectification works. Maintenance schedules for all assets were also prepared. This project won the Stormwater Victoria 2015 award for "Excellence in Asset Management". The **Judges Citation is a follows:**

"Hume City Council, Optimal Stormwater and Stormy Water Solutions' WSUD Asset Audit and Rectification Project with support from Melbourne Water's Living Rivers Program, has brought real asset management principles to the WSUD asset class with tangibility and affordability. The project was undertaken in a highly collaborative way from the get go, ensuring support and alignment across Council. The project was delivered with low cost and significant outcomes including a happy community and a safer place. Management of WSUD assets is an industry wide issue. This project provides a great low cost and attainable exemplar of how this can be done.

Major Wetland and WSUD Strategy Development, Wyndham City Council

Valerie worked on three major waterway rehabilitation projects within Wyndham City Council from 2004 to 2007. These projects required investigating possible application of WSUD to existing drainage assets within the area. The projects included the D1 Drainage Scheme WSUD Drain Rehabilitation Strategy, The Werribee Floodway WSUD Drain Rehabilitation Strategy and the Lollypop Creek WSUD Drain Rehabilitation Strategy. Following the successful adoption of the Lollypop Creek Strategy, Valerie completed the functional design and supported Council in the detailed design of 5 major wetland systems along Lollypop Creek. These wetlands will replace the existing concrete drain. These wetlands were constructed very successfully by Council in between 2005 and 2007. Council and Stormy Water Solutions were awarded the Stormwater Industry Award (both state and national awards) for this wetland design in late 2007.

Use of Class A Recycled Water – Hunt Club Estate Cranbourne

Recycled water has relatively high nutrient concentrations which can affect stormwater runoff characteristics. Valerie Mag was engaged to investigate the impact of a major initiative of the Hunt Club Estate to use utilise Class A recycled water (recycled water) within the development for residential and school garden watering and oval irrigation.

Valerie fully understood that a robust, clear and transparent investigation of this complex issue could clarify some of the myths and misgivings about this issue. All parties (including referral bodies) were shown that application of recycled water would not result in adverse stormwater impacts. This has resulted in the adoption of a scheme which will result in potable water saving within this site of over 150

ML/yr. However, the knowledge gained also facilitates easier application of this technique on other proposed large scale development projects in Victoria and therefore potentially help achieve in massive savings in portable water use within Victoria in the future.

Wellington Road Duplication, Vic Roads

In July 2004 Valerie completed the concept design and MUSIC modelling of the of the WSUD elements proposed within the Duplication of Wellington Road for Vic Roads. The project utilised sediment collection pits, swales and areal bioretention systems to mitigate the impact of pollutant loads on downstream waterways.

This project required particular consideration of vehicular access issues, WSUD asset protection and car safety issues. Additional issues included the many service constraints within the road reserve, road reserve limitations and adjacent property owner concerns.

Cardinia Industrial Area Drainage Strategy (Pakenham)

Valerie was jointly retained by both Cardinia Shire Council and Melbourne Water in late 2007 to develop a comprehensive drainage, flood mitigation and WSUD strategy for this major future development west of Pakenham. Her contribution included merging the environmental aspects of the development with the civil engineering, landscape, urban planning and council vision. She was involved in negotiations and workshops involving Council and all major stakeholders. She was the primary designer of the adopted WSUD strategy for the development, and developed the major wetland, pond and vegetated channel designs which now form a major part of the adopted Melbourne Water Corporation Development Services Scheme (also developed by Stormy Water Solutions).

Afton Street Conservation Park Wetland Design (Mooney Valley)

The City of Mooney Valley engaged Valerie to complete all the hydrologic and hydraulic modelling required for the concept and functional design of the combined wetland/irrigation pond within this extremely high profile site. Stormy Water Solutions has also produced all functional design drawings for the asset. This design work was completed in July 2008, with detailed design and wetland construction completed (by Council) in 2010. Council and Stormy Water Solutions received a Merit award in 2009 from Stormwater Victoria in the “Master Planning and Design” category.

CATCHMENT AND FLOODPLAIN MANAGEMENT

Drainage Scheme Development (Metropolitan Melbourne)

Valerie has been responsible for developing many Melbourne Water drainage schemes. Work included undertaking hydrologic and hydraulic analysis, stakeholder consultation, multi-disciplinary team coordination including coordinating environmental input, determining cost estimates and drainage scheme rate recommendations and producing the functional design of major retarding basins and wetland systems required for the implementation of Drainage Schemes in Greenfield and developed areas. Drainage Schemes developed include Braeside South Drainage Scheme (Braeside), Braeside

Drainage Scheme (Braeside), Collison Road Drainage Scheme (Cranbourne), Laurimar Drainage Scheme (Whittlesea), Shakespeare Grove Main Drain Drainage Scheme (St Kilda), and the Homestead Road Drainage Scheme (Berwick).

Urban and Rural Floodplain Studies (Metropolitan Melbourne and rural Victoria)

Valerie has completed numerous flood plain studies for Melbourne Water in both urban and rural areas. Development of hydrologic models (RORB) and hydraulic models (Hec Ras and MIKE 11) have been required. She has also been involved in the internal processing and public consultation required for major flood plain and overland flow path declaration projects such as Deep Creek Flood Plain (Pakenham), Grasmere Creek Flood Plain (Berwick), Merricks Creek Flood Plain (Hastings) and various overland flow path planning overlays within Melbourne.

ADDENDUM 1 Lindum Vale, Mickleham, Independent Hydrologic Assessment, Stormy Water Solutions, 21 May 2015

Lindum Vale, Mickleham
Independent Hydrologic Assessment

21 May 2015

Report by: Valerie Mag BE Civil (Hons), M Eng Sci

Stormy Water Solutions

Ph 9511 5911, M 0412 436 021

Contents

1. Introduction

In May 2015 Hume City Council requested Stormy Water Solutions to undertake an independent assessment of the drainage strategy proposed for the Lindum Vale PSP area. Of particular concern are the 208 river Red Gums on site.

A full ecological assessment of the requirements of these trees in regard to long term health is required. However, at the planning stage it is understood that flow regimes (groundwater feed, minor flow watering and major flow inundations) are required to be closely replicated if the trees are to remain healthy in the long term.

The current drainage proposals are detailed within “Stormwater Strategy, Lindum Vale, September 2014” prepared by Dalton consulting Engineers Pty Ltd (DCE).

This proposal is generally in line with current design practice which is to pipe subdivisional drainage to a defined outfall point, where a combined retarding basin/wetland system provides stormwater treatment and flow retardation.

This approach can work in most subdivisions where major and minor event drainage infrastructure can be designed independently. However, Council is concerned that, in this case, the PSP’s approach to planning for the 100 year ARI events will lock-in a suboptimal approach to managing minor events. This may result in PSP proposals which “design out” passive irrigation options for the trees. How the major and minor drainage systems can work together to achieve additional ecological outcomes has yet to be fully understood.

Council supports the preparation of an Integrated Water Management Strategy (IWMS) for this PSP. The IWMS would inform the PSP’s objectives and requirements for drainage infrastructure and would include:

- minimising alterations to the natural topography,
- ensuring tree’s identified for preservation are retained and their health is not impacted on by cut and fill,
- ensuring trees are adequately irrigated, and
- all other ecological values are identified and confirmed going forward.

This report specifically looks at a possible alternative way to view the drainage strategy in a decentralised way to achieve the above objectives. It has been prepared for discussion purposes only at this stage.

The comments and assessments made within this report are only the opinions of Valerie Mag and are based on hydrological calculations and her 25 years' experience in the drainage and waterway engineering fields. All comments within this report, are preliminary only, and subject to change given changes in the modelling assumptions detailed below.

2. Background

Valerie Mag is the author of this report. Valerie has twenty five years' experience and expertise in hydrologic and hydraulic engineering, particularly in the areas of:

- Preparing complex urban and rural flood plain strategies,
- Major catchment analysis, including flood flow and flood level estimation,
- Planning and assessment of development within flood plain and waterway systems,
- Regularly preparing and conducting training in drainage and WSUD for the ARRB Group, Municipal Association of Victoria, Vic Roads, Melbourne Water, the Department of Tourism Arts and the Environment (Tasmania) and others.

The assessment is a high level overview only. The following has been taken into consideration in regard to this assessment:

- Discussions with Hume City Council officers in May 2015,
- 1 m contour information obtained in AutoCAD format from the DEPI web site,
- Property boundary information obtained from the DEPI web site,
- Existing tree locations as defined by Council (AutoCAD)
- the "Stormwater Strategy, Lindum Vale , September 2014" prepared by Dalton consulting Engineers Pty Ltd and various plans and emails to Council which have expanded on this report, and
- Probable internal pipe drainage locations of the subject site determined from both probable reserve locations and current PSP proposals (pdf files)

The above information is relatively peace-meal and somewhat incomplete. However, enough investigation has been undertaken to make reasonable assumptions in relation to realistic future internal catchment boundaries etc. The report is also based on hydraulic calculations conducted by Valerie Mag to understand the approximate subdivisional pipe capacities and the retarding basin inlet and outlet systems.

Valerie Mag has had no previous involvement in the site, however she is familiar with the Malcom Creek Catchment.

3. Possible Alternative Drainage Strategy

Figure 1 below details a possible alternative drainage strategy. The assumed development and drainage configuration is based on the information above, and is considered reasonable representation of what could be achieved given the current PSP proposals.

The analysis below only considers the northern catchment as defined by DCE.

As detailed, some minor changes /additions to the required reserve areas are shown. However, the major difference with current proposals is the catchment delineation, subdivisional pipe sizes and treatment of minor flows as discussed in the remainder of this report.

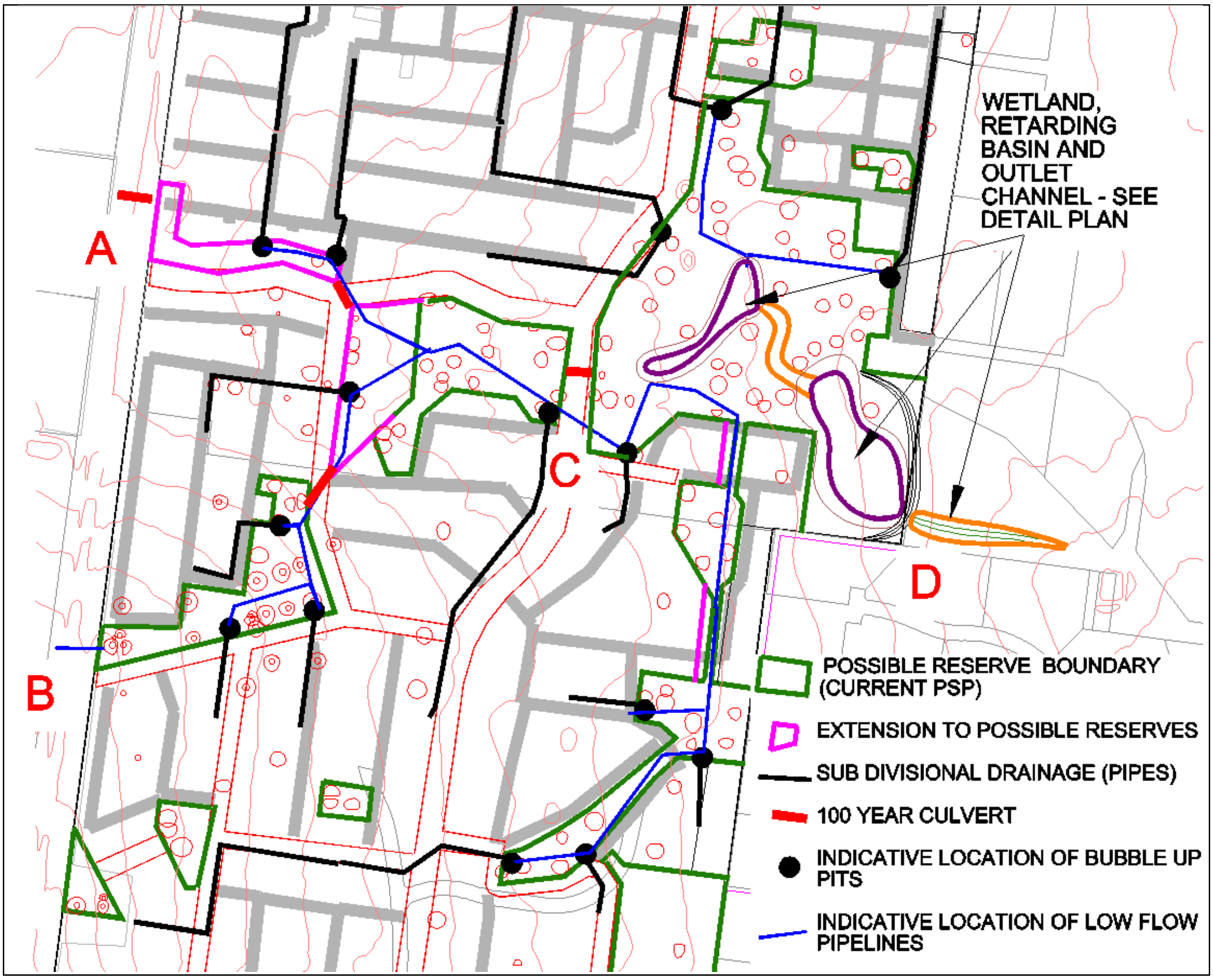


Figure 1 Possible Alternative Drainage Strategy, SWS May 2015

The strategy is based on the following methodology detailed in the following sections.

4. External Catchment Requirements

The external catchment is in the order of 82 ha, and enters the site on the western boundary via an existing shallow culvert system at Point A.

It is considered that many of the trees on site are surviving because this external catchment is passively watering the trees. As such, it is seen as very advantageous to maintain this "surface connection".

Consideration should be given to providing a shallow channel connection from the road culvert to the downstream reserve (as currently defined in the PSP proposals).

This channel only has to be capable of conveying 4.15 m^3/s (100 year ARI flow – See Appendix A). As such, a 15 m wide channel (1/200, 0.4 deep, 1 in 5 batters) located adjacent to an access road would be sufficient to achieve this connection. Adjacent lots would require 600 mm freeboard to the top of bank.

There also appears to be a significant sheet flow input around the vicinity of Point 2. This has allowed the trees on the site of the hill to take hold. Provision of a shallow three month culvert under Mickleham Road at Point B could help maintain this connection. Alternatively, the flow regimes to these trees could be mimicked via the incorporation of the lot pipe connection designs proposed below.

5. Internal Catchment Requirements

The drainage strategy detailed relies on a fundamental principal of allowing stormwater to passively water the trees on site. In many cases this could be undertaken via sheet flow from adjacent one way cross fall roads etc. However, in general this will not be enough to water every tree.

As such, it is proposed to use the subdivisional drainage system to facilitate passive tree watering. This can be done via:

- Minimising contributing catchment area to minimise pipe sizes,
- Minimising pipe cover (600 mm max to natural surface level), and
- Using the above two design principals to keep the piped drainage system invert levels as shallow as possible.

A possible catchment breakdown is shown in Figure A.1 (RORB Model). This delineation has been formulated given the preliminary PSP reserve and road alignments, and therefore is considered feasible to this application. Preliminary investigations suggest that most subdivisional pipelines would be 450 – 600 mm diameter at their outfalls to the reserve. At the worst case (i.e. largest catchment detailed), twin 600 mm pipelines could be used. 5 Year ARI Hydraulic Grade Line (HGL) analysis of all pipelines will be required during the design process (given a tail water level at just above the natural surface in the reserve).

These pipes would be placed on the edge of the reserve in locations where spillage from them will feed as many trees as possible. Slight surface shaping in the reserves could help spread the surface water input.

6. Reserve Bubble Up Pits and Low Flow Bypass System

Shallow pipeline systems are required so that bubble up of surface flows can occur in a simple and easy fashion. If the pipe invert level depth is kept to in the order of 1.0 – 1.2 metres below the natural surface level, then it is considered that bubble up pits as detailed in Figure 2 could be utilised.

The key requirements of the bubble up pits are:

1. to encourage groundwater infiltration via the use of a bottomless pit and the aggregate/screening base as detailed,
2. to provide local sump areas for sediment deposition and a facility to ensure easy removal of this pollutant during maintenance activities,
3. to provide a low flow bypass mechanism which ensures upstream pipelines are dry in-between storm events and ensures trees are not “over watered”,
4. to provide a mechanism where flow bubbles up out of the pits in most storm events and is distributed as sheet flow into the reserves to water the trees.

An alternative to providing a sump area for sediment deposition (Point 2. above) is to provide wet sump vortex gross pollutant traps (GPT’s) on all pipe outfall) just upstream of the bubble up pits. This is a more expensive option, but would guarantee sediment removal, and supplement the pollutant removal efficiency detailed in Appendix B.

Allowing all flow from the development to the reserve surface may result in overwatering of the trees (in some cases). As such, the low flow bypass pipeline (and possibly the infiltration screening mechanism) should be designed to bypass a small amount of flow and allow surface flow to the treed areas at a rate/annual volume which mimics the existing situation. This analysis would be based on a daily water balance and is outside the scope of this report. However, at this stage, a low flow bypass in the order of 20% of the estimated 3 month flow (see Appendix A) is assumed. As such, it is expected that once or twice a month surface flow would engage the treed area.

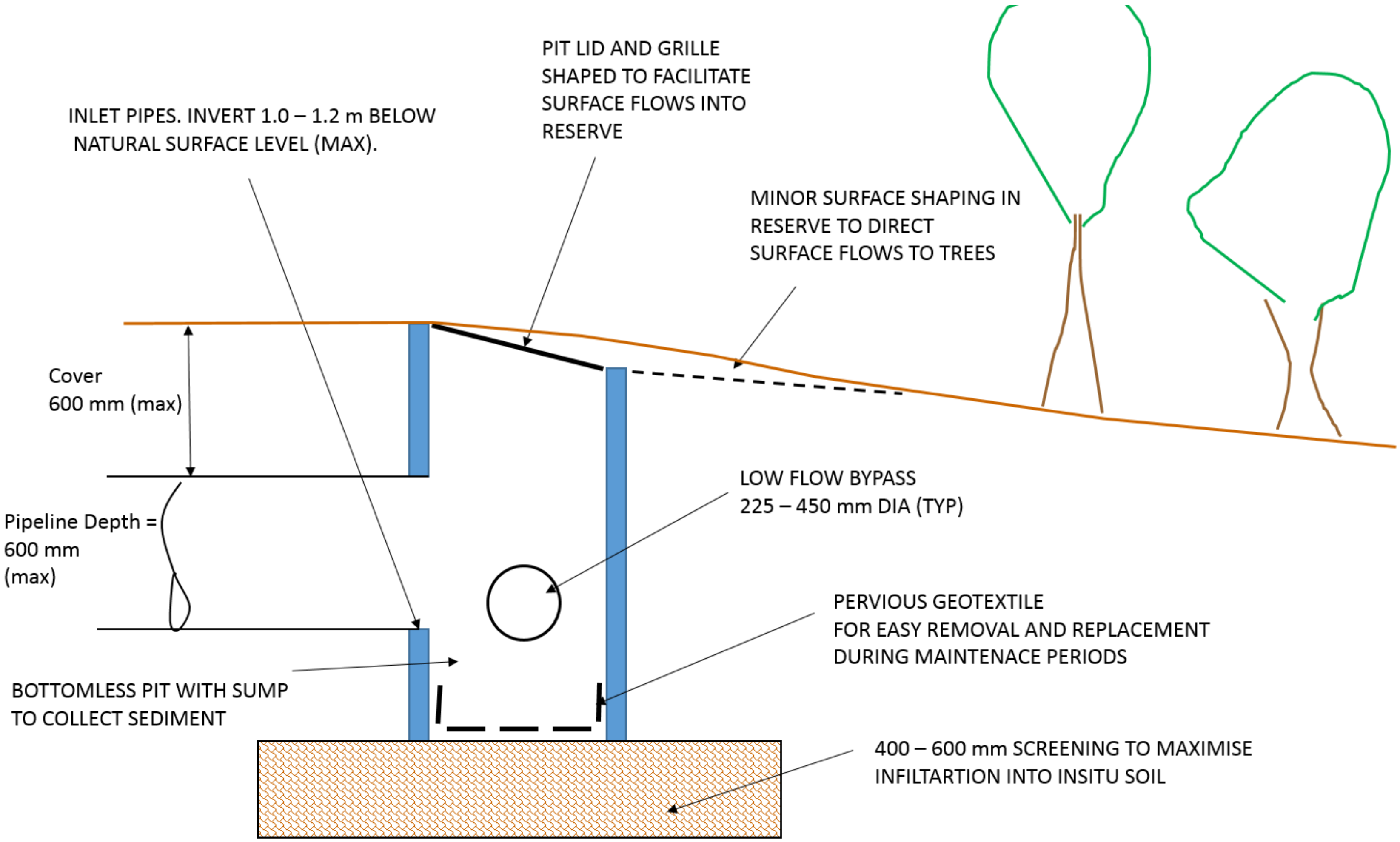


Figure 2 Concept Design of Bubble-Up Pits

7. Surface Flow in Reserves

Facilitating both low flow and high flow at surface in the reserves obviously has the benefit of allowing tree watering.

However there are two major drainage benefits. The first is that stormwater pollutant treatment occurs as the stormwater flows over the grassed surface. In MUSIC this can be modelled as “swale” treatment. The width of the sheet flow can be significant resulting very good stormwater pollutant removal given the very simplistic nature of this mechanism. The obvious benefit is a resultant reduction in the wetland system area required downstream at the outlet (see Appendix B).

Melbourne Water do not usually attribute any stormwater treatment to flow in drainage reserves. This is because waterways in reserves are designed as vegetated channels. Vegetated channels are generally treated as “receiving bodies” rather than treatment elements. However, this system is not a “vegetated channel”. It is sheet flow over an extensive grassed surface. If not modelled as a “swale” the resultant increase in downstream sediment pond and wetland area could result in loss of River Red Gums due to the sediment pond/wetland construction. It would be a shame if trees were lost due to a model not accounting for what will actually physically happen.

The second major benefit is that, even in very large flow events, the flood waters are now allowed to move very slowly through the subdivision. Flow may move in the order of 0.5 – 0.7 m/s over the grassed surface as sheet flow, as opposed to 2.5 – 3.0 m/s within a conventional piped system of a similar slope. This “slowing down” of the flow complements the natural storage effect of the catchment, providing an effect not unlike the provision of a retarding basin. Appendix A shows the expected flow reductions predicted by RORB due to the provision of a naturalistic flow path rather than a structural flow path. The other major benefit is a resultant reduction in the retarding basin provisions required downstream at the outlet (see Appendix A). Again, there is NO tree loss due to the retarding basin design.

This is a very good example of a drainage system where there are benefits in not viewing or designing the major and minor systems as separate entities. It also represents a significant change in how we currently design subdivisions. In nature, major and minor flows are conveyed in the same mechanism. Why should we not replicate this in subdivision design?

8. Wetland/Retarding Basin Design

The concept design the retarding basin/Wetland system is detailed in Figure 3.

The design is based on the RORB and MUSIC modelling detailed in Appendices A and B assuming "natural" reserve reaches in RORB model and upstream "Swale treatment with low flow bypass" in MUSIC. As such, the sizes detailed imply due consideration of the upstream drainage and catchments as detailed in this report.

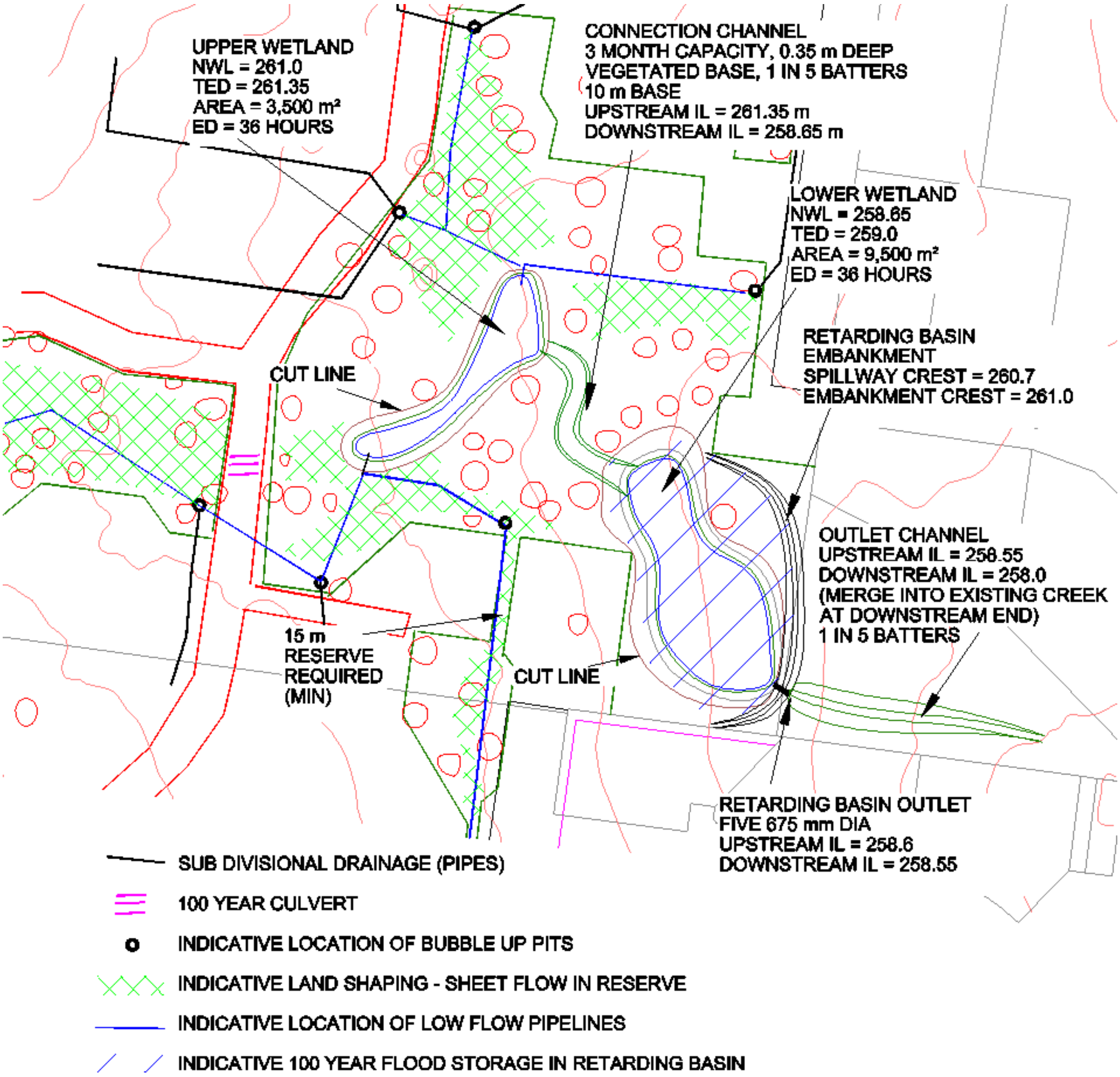


Figure 3 Concept Design – Wetland/Retarding Basin at Site Outfall

All levels relative to an assumed natural surface level of 160.3 m AHD at the property boundary as defined by the 1 metre DEPI contours

Additional upstream WSUD initiatives such as tanks for toilet flushing and/or wet sump vortex GPT's upstream of the bubble up pits would reduce the wetland system size from that detailed.

Allowing for passive watering of trees in the reserves provides the opportunity to take advantage of the flood mitigation and swale treatment this allows. This results in a retarding basin/wetland design which can be easily configured to ensure no existing trees are lost due to construction within the site immediately upstream of the site outfall.

It should be noted that, although inlet zones have been allowed for in the upper wetland, these areas will not need to be designed as “sediment ponds”. Sediment collection is proposed to occur in the bubble up pits in this strategy (or possibly wet sump vortex GPT’s upstream of the bubble up pits). That is, sediment will be addressed at the upstream end(s) of the reserve system, rather than at the downstream end. As such, specific dewatering areas for sediment cleanout should not be required.

It should be noted that the proposed low flow bypass system could be extended to allow for provision of wetland draining which is required during wetland maintenance periods.

At this stage a wetland bypass channel is not proposed. As such the concept design is “not deemed to comply” with the standard requirements in the current MWC 2015 wetland design manual. This does not mean a design such as this will not be approved by MWC. It just means that more work is required to be done to show various wetland requirements can be met incorporating this design. Primarily this relates to 3 month and 100 year velocity determination over the wetland system and a vegetation inundation analysis. However, it is expected that MWC requirements in regard to wetland design can be met going forward.

9. Outlet Channel Design

Figure 3 details the outfall drain augmentation requirements to achieve the stage/discharge relationship for the retarding basin detailed in Appendix A.

Examination of the 1 metre contour information indicates that a 1/350 slope can be achieved between the invert level of the proposed retarding basin outlet and the existing channel invert 200 m downstream. No additional pipe work is required. The flattening out of the existing invert results in a relatively low invert at the retarding basin. As such, a retarding basin/wetland design more in line with DCE Option 2 can be accommodated, without the need for downstream pipelines.

The concept design of the channel longitudinal section is detailed in Figure 4. As shown in Figure 3, the channel land take within the reserve downstream of the site should have minimal impact on current reserve ecological attributes.

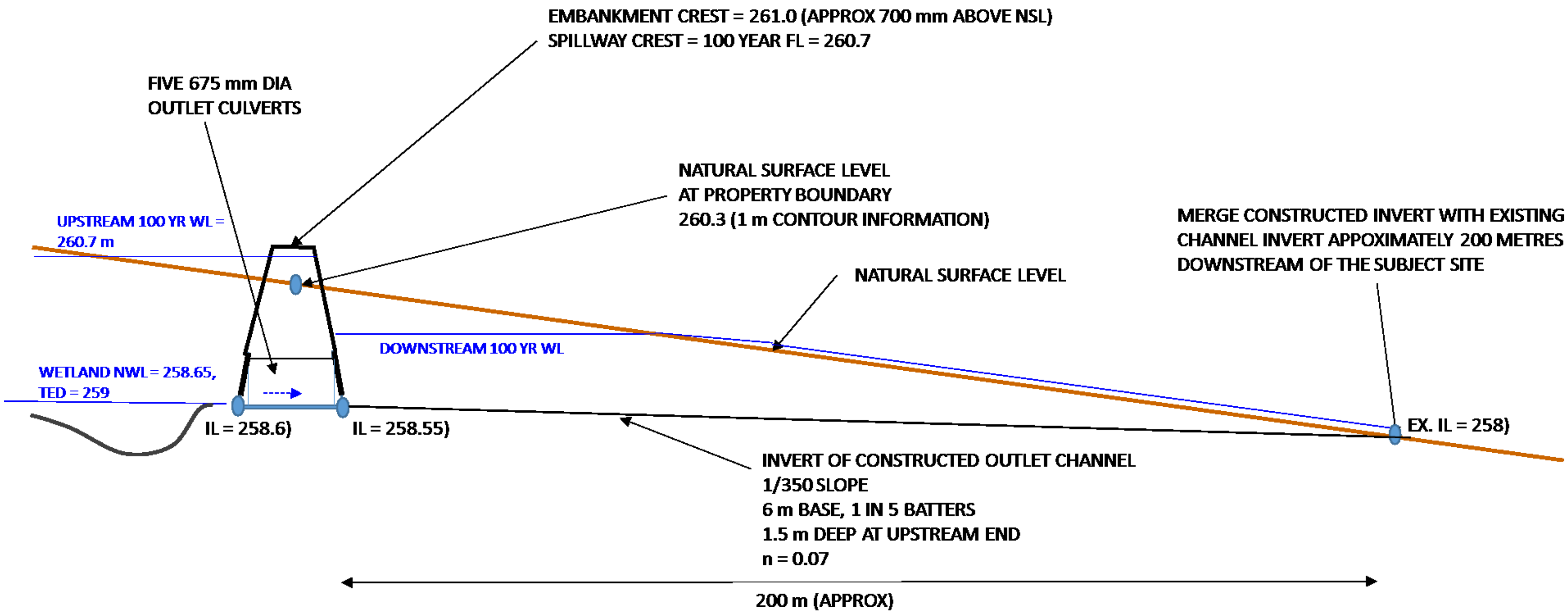


Figure 4 **Concept Design of Outlet Channel**

All levels relative to an assumed natural surface level of 160.3 m AHD at the property boundary as defined by the 1 metre DEPI contours

10. Fill and Flood Protection

It is recommended that a model such as TuFlow be used to confirm the design flows predicted in this analysis (given the assumption of the benefits of naturalistic reaches reducing flood flows etc.). This TuFlow model can then also be used to assess:

- flood depths in the reserves and determine minimum reserve width requirements at "pinch points", and
- design flood levels and required fill levels adjacent to the reserves.

At this stage preliminary Manning formula anaysis indicates:

- at least 15 metre grassed channel connections are required beween major reserve areas to ensure flows continue at surface from one section of the reserve to the next, and
- in general, 100 Year ARI flood levels will be at or about natural surface level at the edge of the reserve, resulting in lot levels being required to be in the order of 600 mm above the adjacent reserve boundary level.

11. Road Culverts

There will be about three 100 year ARI road culverts required within the subdivision.

These culverts will need to be designed to ensure the methodology of maintaining the low flow bypass system and the surface flow feed to the trees is maintained. In addition, 100 year ARI backwater effects due to the culvert systems and road heights across the reserve should be minimised.

Figure 5 below is a concept design of the culvert at Point C (Figure 1). As detailed, it is expected that the 100 year road culvert systems can be designed in this way and not compromise the alternative strategy. A culvert such as this could also be used if the Mickleham Road culvert is required to be upgraded in the future.

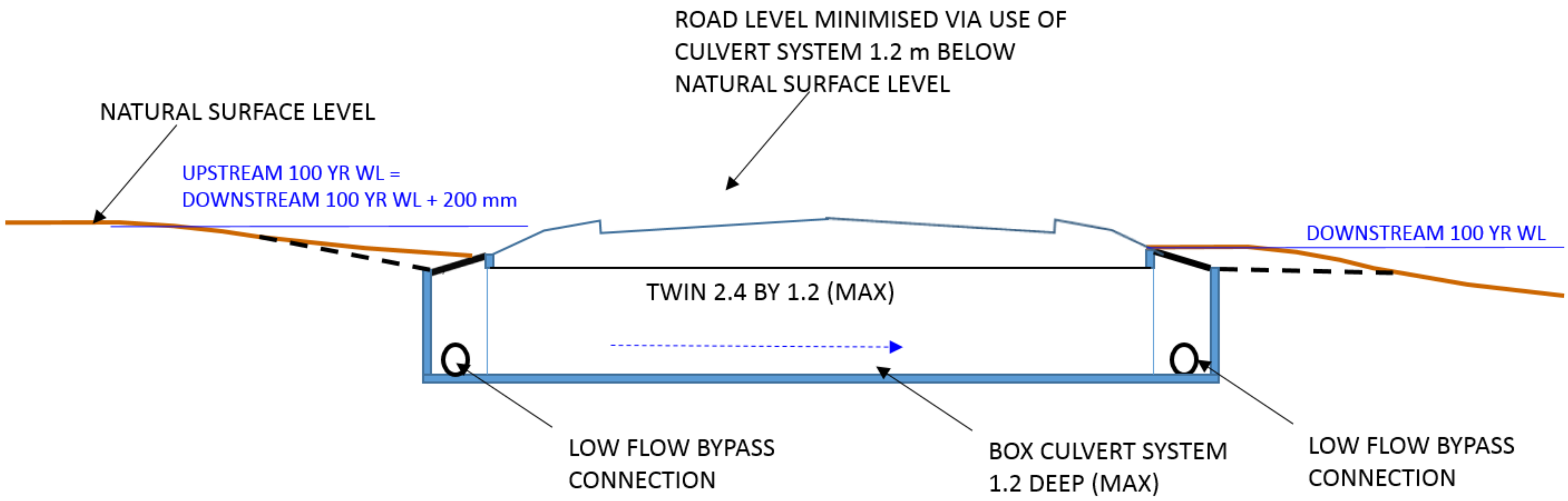


Figure 5 Concept Design of 100 Year Road Culvert (Point C, Figure 1)

12. Reserve Landscape

In facilitating surface flows, there may be significant areas which are relatively “wet” in the reserve over the course of a year. This obviously hampers mowing activities and reserve access.

Rather than a design constraint, this should be seen as an opportunity to encourage establishment of native grasslands etc. The final “look” of the reserve could be very similar to what would have been observed 200 years ago being river red gums and native grass (and other appropriate vegetation).

Access paths set at the 10 year ARI flood level and slightly elevated boardwalk systems over and through the grassland areas would control people movement thought the reserve area.

Obviously these are just some high level landscape ideas. However, it is hoped that the proposed alternative drainage strategy in this report facilitates discussion into the way the drainage system can be an opportunity to enhance the subdivision, rather than a constraint.

13. Conclusions

This analysis has been a desk top exercise designed to show that passive watering of the existing river red gums on site can occur within the subject site.

The analysis suggests, given minor changes to the reserve layout and configuration, both minor and major surface flows can be conveyed though the site generally within the existing subdivision PSP proposals.

The major change in regard to the project is the way in which the drainage system is designed and implemented. To achieve the ecological and hydrological benefits detailed in this report all of the recommendations discussed are required to be adhered to. In particular subdivision catchments, pipe sizes and pipe depths must be minimised.

This aspect of the design requires diligent and specific consideration of the road, drainage and subdivision catchment delineation and pipe alignments at an early stage in the design process. The methodology advocated within the report is required to be adhered to during ALL stages of the design and construction process.

The “engineering” suggested in this report is not complex. The major barrier to implementation of a scheme such as this is that it is different from how the industry currently applies drainage provisions within a site, and therefore requires a slight shift in project approach and application in all the professionals and organisations involved.

APPENDIX A FLOW MODELLING

The following details the assessment of the design flows for, and downstream of, the subject site.

A.1 RORB Model Description

Figure A.1 details the RORB model. Tables A.1 and A.2 detail the RORB Setup.

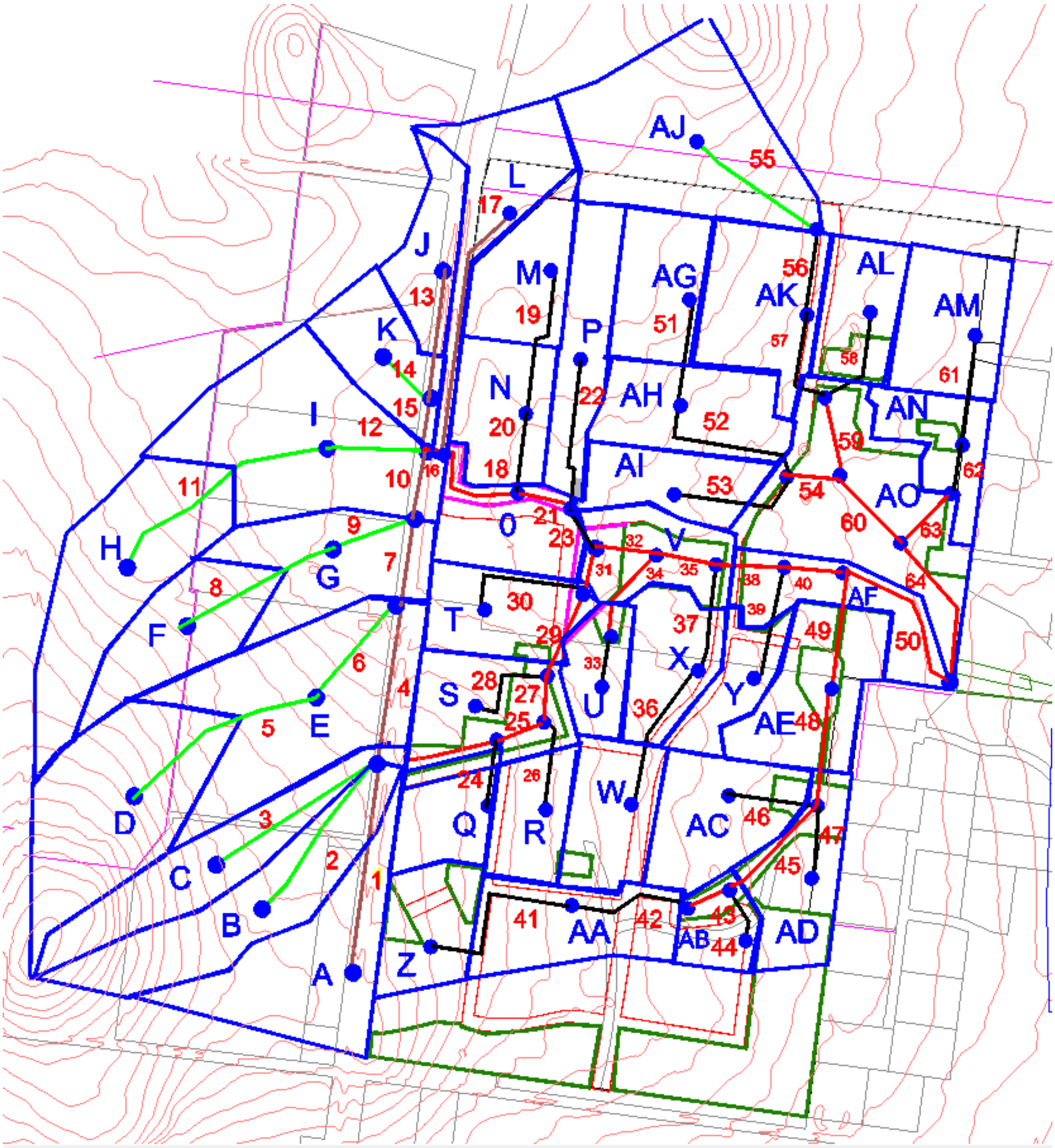


Figure A.1 **RORB Model**

Note: model assumes small distributed catchments at Per Figure 1

Table A.1 RORB Model Setup - Subareas

Sub Area	Area (ha)	Area (km^2)	Fraction Imperviousness		Sub Area	Area (ha)	Area (km^2)	Fraction Imperviousness
A	7.4	0.0740	0.05		AA	5.1	0.0510	0.80
B	7.2	0.0720	0.05		AB	2.1	0.0210	0.45
C	5.8	0.0580	0.05		AC	5.1	0.0510	0.75
D	9.3	0.0930	0.05		AD	4.5	0.0450	0.50
E	10.9	0.1090	0.05		AE	5.5	0.0550	0.65
F	5.0	0.0500	0.05		AF	4.0	0.0400	0.05
G	5.7	0.0570	0.05		AG	4.1	0.0410	0.80
H	8.7	0.0870	0.05		AH	5.1	0.0510	0.80
I	10.5	0.1050	0.05		AI	3.5	0.0350	0.80
J	3.2	0.0320	0.05		AJ	10.7	0.1070	0.05
K	3.9	0.0390	0.05		AK	5.8	0.0580	0.80
L	5.1	0.0510	0.05		AL	3.6	0.0360	0.65
M	4.0	0.0400	0.80		AM	4.9	0.0490	0.80
N	4.3	0.0430	0.80		AN	3.1	0.0310	0.75
O	4.1	0.0410	0.60		AO	10.0	0.1000	0.10
P	4.3	0.0430	0.80					
Q	3.2	0.0320	0.80					
R	3.1	0.0310	0.80		**Fraction Impervious based on:**			
S	5.5	0.0550	0.50		Rural =	0.05		
T	4.2	0.0420	0.75		Development =	0.8		
U	2.4	0.0240	0.65		Reserve =	0.05		
V	3.9	0.0390	0.25					
W	4.1	0.0410	0.75					
X	3.8	0.0380	0.80					
Y	2.6	0.0260	0.80					
Z	3.6	0.0360	0.65					
Total:	**212.90**	**2.13**	**0.47**					

Table A.2 RORB Model Setup - Reaches

Reach	Length (m)	Fall (m)	Length (km)	Slope (%)	Reach Type	Reach	Length (m)	Fall (m)	Length (km)	Slope (%)	Reach Type
1	390	2.5	0.39	0.6%	EX/UNLINED	33	85	1	0.09	1.2%	PIPED
2	340		0.34		NATURAL	34	190	1	0.19	0.5%	RESERVE
3	360		0.36		NATURAL	35	110	0.5	0.11	0.5%	RESERVE
4	270	4	0.27	1.5%	EX/UNLINED	36	275	0.5	0.28	0.2%	PIPED
5	390		0.39		NATURAL	37	195	1.5	0.20	0.8%	PIPED
6	200		0.20		NATURAL	38	120	0.5	0.12	0.4%	RESERVE
7	155	0.3	0.16	0.2%	EX/UNLINED	39	220	1	0.22	0.5%	PIPED
8	310		0.31		NATURAL	40	100	1	0.10	1.0%	RESERVE
9	150		0.15		NATURAL	41	340	3.5	0.34	1.0%	PIPED
10	120	0.3	0.12	0.3%	EX/UNLINED	42	220	2	0.22	0.9%	PIPED
11	440		0.44		NATURAL	43	75	0.5	0.08	0.7%	RESERVE
12	170		0.17		NATURAL	44	100	0.5	0.10	0.5%	PIPED
13	240	1.3	0.24	0.5%	EX/UNLINED	45	200	1.5	0.20	0.8%	RESERVE
14	115		0.12		NATURAL	46	165	1	0.17	0.6%	PIPED
15	90	0.3	0.09	0.3%	EX/UNLINED	47	130	0.5	0.13	0.4%	PIPED
16	20	0.3	0.02	1.5%	PIPED	48	215	1	0.22	0.5%	RESERVE
17	460	2	0.46	0.4%	EX/UNLINED	49	210	1	0.21	0.5%	RESERVE
18	240	1.3	0.24	0.5%	RESERVE	50	295	1.5	0.30	0.5%	RESERVE
19	250	1.3	0.25	0.5%	PIPED	51	185	2	0.19	1.1%	PIPED
20	140	1.3	0.14	0.9%	PIPED	52	285	3	0.29	1.1%	PIPED
21	90	0.3	0.09	0.3%	RESERVE	53	240	2	0.24	0.8%	PIPED
22	280	2	0.28	0.7%	PIPED	54	100	1	0.10	1.0%	RESERVE
23	80	0.3	0.08	0.4%	PIPED	55	240		0.24	0.0%	NATURAL
24	120	0.5	0.12	0.4%	PIPED	56	150	1	0.15	0.7%	PIPED
25	85	1	0.09	1.2%	RESERVE	57	190	1	0.19	0.5%	PIPED
26	180	0.3	0.18	0.2%	PIPED	58	200	0.5	0.20	0.3%	PIPED
27	80	1	0.08	1.3%	RESERVE	59	140	0.7	0.14	0.5%	RESERVE
28	190	2	0.19	1.1%	PIPED	60	160	1	0.16	0.6%	RESERVE
29	160	1.5	0.16	0.9%	RESERVE	61	200	0.5	0.20	0.3%	PIPED
30	250	1.5	0.25	0.6%	PIPED	62	100	0.3	0.10	0.3%	PIPED
31	85	0.5	0.09	0.6%	RESERVE	63	110	0.5	0.11	0.5%	RESERVE
32	113	0.6	0.11	0.5%	RESERVE	64	260	1	0.26	0.4%	RESERVE

As detailed in Table A.2, development reaches are defined as “Piped”, road drains are defined as “excavated unlined” and rural reaches as “natural”. “Reserve” reaches have been defined separately. This is because a sensitivity analysis as detailed in Section A.2 has examined the sensitivity of design flows to the definition of the reach types in the reserve.

The RORB model parameters are based on the regional parameter developed by Melbourne Water for the northern and western region of Melbourne.

- $K_c = 1.19A^{0.56} = 1.82$ (2.13 km^2)
- m = 0.8
- Initial loss = 15 mm
- Pervious area runoff coefficient (C_{perv})
    - 100 year ARI C_{perv} = 0.6
    - 1 year ARI Cperv = 0.2

ARR 1987 areal reduction factors were used. Yuroke rainfall intensities were utilised. Filtered rainfall patters with Siriwardena and Weinmann Areal Reduction (0 km^2) were incorporated.

A.2 100 Year ARI Design Flows

The RORB results are detailed in Table A.3 below.

Location	1. Upstream 18	2. End 23	3. Upstream 32	4. Upstream 38	5. End 50	6. Upstream 60	7. End 64	8. Outlet
100 Year Flow (undeveloped catchment) (m^3/s)	3.15	3.49	4.20	4.50	5.31	1.43	1.82	6.96
Critical Duration	2 hr	9 hr	9 hr	2 hr	9 hr	2 hr	2 hr	9 hr
100 Year Flow (Piped Reserve Reaches) (m^3/s)	4.15	5.22	8.91	11.40	15.93	6.12	8.85	24.15
Critical Duration	1 hr	2 hr	15 min	25 min	25 min	15 min	25 min	20 min
100 Year Flow (Ex/Unlined Reserve Reaches) (m3/s)	4.15	5.04	7.17	8.25	11.35	5.42	6.17	16.81
Critical Duration	1 hr	2 hr	25 min	1 hr	1 hr	15 min	1 hr	1 hr
100 Year Flow (Natural Reserve) (m^3/s)	4.15	4.36	5.41	5.95	7.23	4.01	3.76	9.94
Critical Duration	1 hr	2 hr	2 hr	2 hr	2 hr	2 hr	1 hr	2 hr

Table A.3 100 Year ARI Flow Estimates

The “undeveloped” catchment flow at the outlet is estimated at 7.0 m^3/s. This is less than the 10 m^3/s calculated by DCE, and therefore probably on the conservative side in regard to retarding basin requirements.

Table A.3 clearly demonstrates the benefits of incorporating a “trunk” drainage system which mimic “natural” reaches. This “slowing down” of the flow complements the natural storage effect of the catchment. The 100 year flow at the catchment boundary reduces from 24.2 m^3/s to 9.9 m^3/s just through slowing the water down and supplementing the catchment storage effect with a sizable reach storage effect.

It is considered that, as the low flow bypass system will only be designed to take in the order of 20% of the 3 month flow, modelling the “reserve” reaches as “natural” is justified.

The above results should be confirmed via analysis of the system with a model such as TuFlow. This model would be required to set flood and fill levels as well.

A.3 Low Flow Bypass System Design Flows

Allowing all flow from the development to the reserve surface may result in overwatering of the trees (in some cases). As such, the low flow bypass pipeline (and possibly the infiltration mechanism) should be designed to bypass a small amount of flow and allow surface flow to the treed areas at a rate/annual volume which mimics the existing situation. This analysis would be based on a daily water balance and is outside the scope of this report. However, at this stage a low flow bypass in the order of 20% of the estimated 3 month flow is assumed. As such, it is expected that once or twice a month surface flow would engage the treed area.

The RORB model was used to calculate the 1 year ARI flows expected in the reserve. This estimate was then used to apply a “rule of thumb” to determine the 3 month ARI flows as detailed in Table A.3. This analysis suggests that the low flow pipes will be required to be in the order of 225 mm – 450 mm diameter. As the low flow pipeline is a pipe, piped reaches are assumed in this model.

Location	1. Upstream 18	2. End 23	3. Upstream 32	4. Upstream 38	5. End 50	6. Upstream 60	7. End 64	8. Outlet
1 Year Flow (Piped Reserve Reaches) (m^3/s)	0.38	1.06	1.89	2.27	3.14	1.41	1.67	4.58
3 Month = 40%1 Year Flow (m^3/s)	0.15	0.42	0.75	0.91	1.26	0.57	0.67	1.83
Low flow Bypass (m3/s) - Passive watering above this flow rate= 20% of the 3 month flow	0.03	0.08	0.15	0.18	0.25	0.11	0.13	0.37

Table A.3 Preliminary Low Flow Bypass Flow Estimate

A.4 Retarding Basin Design

It is assumed that the 100 year design flow is required to be retarded to 7.0 m^3/s at the site outfall. As such, the Stage/Storage/Discharge relationship detailed below was included in the RORB model detailed above. This relationship is based on design contours given the concept design detailed in Figure 3 and the outlet culvert configuration detailed in Figure 4.

Table A.4 Assumed Retarding Basin Stage/Storage/Discharge Relationship

Stage (m)	Storage (m^3)	Discharge (m^3/s)	
258.65	0	0	Wetland NWL
259	0	0	Wetland TED - discharge negligible
259.20	6000	2.0	
259.50	9500	3.0	
259.80	13000	4.0	
260.15	18000	5.0	
260.55	27000	6.0	
260.95	32000	7.0	
262.02	57000	9.1	

As detailed in Table A.5 below, incorporating the alternative upstream drainage strategy (assuming this results in equivalent "natural" reserve reaches) results in less storage provision being required. The major benefit is a in a reduction in associated flood level and embankment height. Site area is not really affected, as this is set primarily by the wetland requirements (See Appendix B)

Table A.5 RORB Results including the Proposed Retarding Basin

Scenario	100 Year ARI Inflow to Retarding Basin Site	100 Year ARI Outflow From Retarding Basin Site	100 Year Flood Level (m AHD)	100 Year Flood Storage (m^3)
Undeveloped catchment	7.0	7.0	n/a	n/a
Critical Duration	Critical Duration = 9 hr	Critical Duration = 9 hr		
Developed Catchment - Piped Reserve Reaches	24.1	7.1	261.00	33,400
Critical Duration	Critical Duration = 9 hr	Critical Duration = 9 hr		
Developed Catchment - Excavated/Unlined Reserve Reaches	16.8	6.95	260.95	31,700
Critical Duration	Critical Duration = 9 hr	Critical Duration = 9 hr		
Developed Catchment - Natural Reserve Reaches	9.9	6.3	260.70	28,600
Critical Duration	Critical Duration = 9 hr	Critical Duration = 9 hr		

APPENDIX B STORMWATER POLLUTANT MODELLING

The performance of the alternative stormwater quality management system outlined in this report analysed using the MUSIC model, Version 5.

Subareas and fraction imperviousness are as detailed in Appendix A above and are consistent with the RORB model.

Sub areas are subject to change given the final development layout, however, provided the catchment delineation methodology as detailed in this report is adhered to, the final MUSIC results are not expected to change significantly.

The sediment collection areas in the bubble up pits were not included in the model, as simple systems such as this do not treat any Total Suspended Solids (TSS), Total Phosphorus (TP), or Total Nitrogen (TN).

Bureau of Meteorology rainfall and evaporation data available in Melbourne Airport (1996) at 6 minute intervals was utilised. This is the reference gauge defined by MWC for this area of Melbourne.

Figure B.1 details the MUSIC model layout developed. Tables B.2 and B.3 detail the assumed model setup.

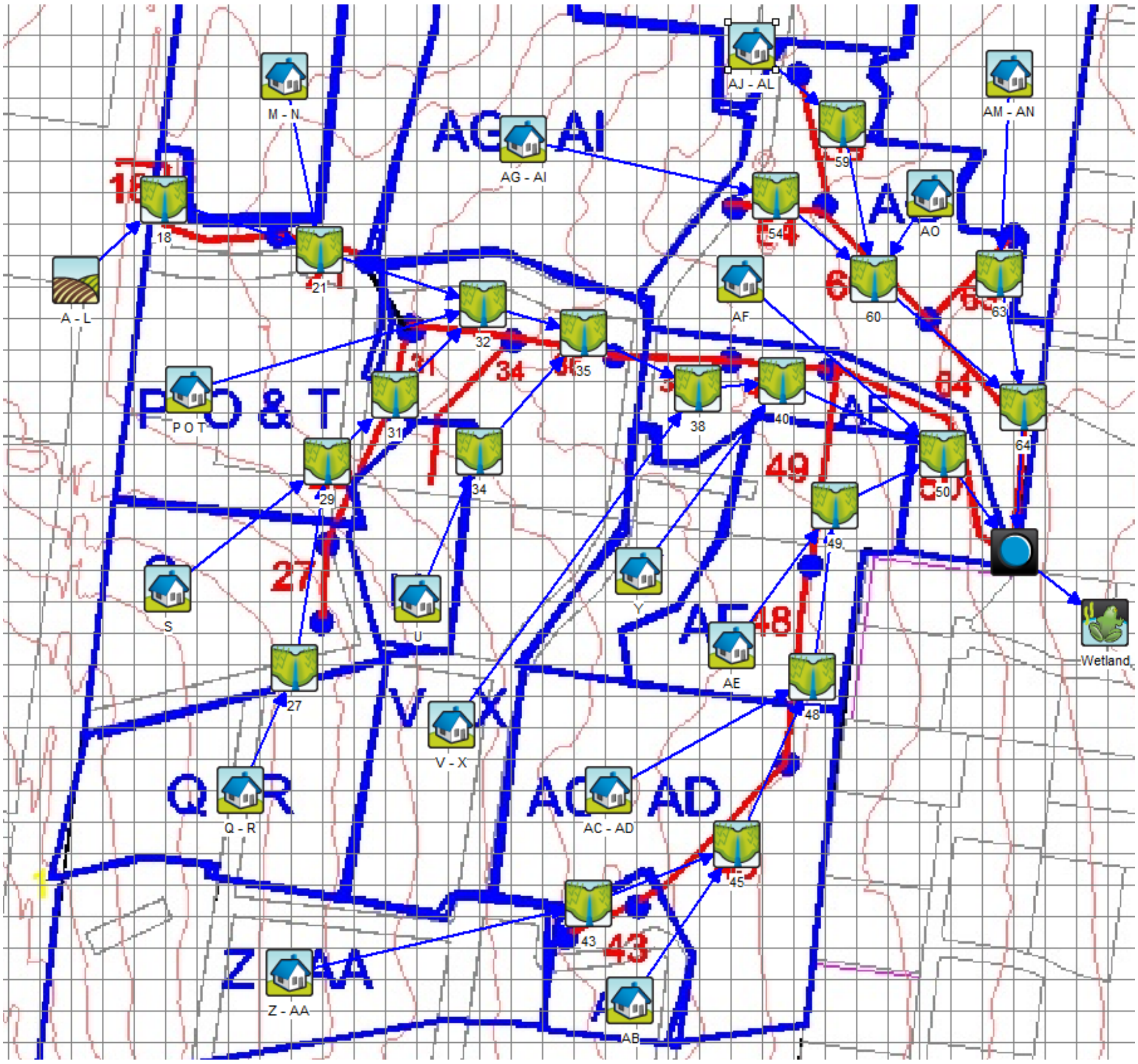


Figure B.1 MUSIC Model

Table B.1 MUSIC Sub Area Definition

Sub Area		Area (ha)	Fraction
			Imperviousness
A - L		82.7	0.05
M - N		8.3	0.80
P, O & T		12.6	0.72
Q - R		6.3	0.80
S		5.5	0.50
U		2.4	0.65
V - X		11.8	0.60
Y		2.6	0.80
Z- AA		8.7	0.74
AB		2.1	0.45
AC - AD		9.6	0.63
AE		5.5	0.65
AF		4.0	0.05
AG - AI		12.7	0.80
AJ - AL		20.1	0.37
AM - AN		8.0	0.78
AO		**10.0**	0.10
Total:		**212.90**	**0.38**

Table B.2 MUSIC Swale Definition

Reach	Swale Length (m)	Slope (%)	Base Width (m)*	Low Flow Bypass (m3/s)**
18	240	0.5%	3	0.03
21	90	0.3%	3	0.08
27	80	1.3%	3	0.07
29	160	0.9%	3	0.07
31	85	0.6%	3	0.07
32	113	0.5%	5	0.15
34	190	0.5%	3	0.03
35	110	0.5%	5	0.18
38	120	0.4%	10	0.18
40	100	1.0%	10	0.18
43	75	0.7%	3	0.05
45	200	0.8%	3	0.05
48	215	0.5%	3	0.06
49	210	0.5%	3	0.07
50	295	0.5%	10	0.25
54	100	1.0%	5	0.05
59	140	0.5%	5	0.06
60	160	0.6%	10	0.11
63	110	0.5%	5	0.02
64	260	0.4%	10	0.13

* For purposes of Pollutant modelling. Flow will actually spread out over a much larger area

** 20% of 3 month flow to bypass to ensure trees not overwatered,
first flush bypasses and pits are dry in-between events

Table B.3 detailed the MUSIC results.

Table B.3 MUSIC Results

Scenario	Assumed Treatment in Swales Upstream of Wetland System	Inlet Zone Requirment at Wetland	Total Wetland Area required to meet best practice ***
1. No Treatment assumed to occur due to Overland flow in the reserves	0 % TSS 0% TP 0% TN	4000 m^{3} = (8000 m^2)*	26,000 (34,000 total)
2. Swale Treatment assumed to occur due to overland flow in the reserves. No Low flow bypass of reserve assumed.	83 % TSS 61% TP 36% TN	0 m^3 **	9,000
3. Swale Treatment assumed to occur due to overland flow in the reserves. Low flow bypass as per Table B.2 assumed.	59 % TSS 47% TP 24% TN	0 m^3 **	13,000

* *Inlet zone required to be designed as a sediment pond to collect all sediment at wetland/retarding basin site. Cleanout every 5 years. Actual site area associated with sediment removal is in the order of 3 times the area of the pond itself. This is due to access track, dewatering area requirements etc.*

** *No sediment pond required at wetland/retarding basin site. Sediment collection provisions at the upstream end of the reserves.*

*** *80% TSS, 45% TP and 45% TN*

As detailed in Table B.3, incorporating the alternative upstream drainage strategy (assuming this results in equivalent “swale treatment with low flow bypass” within the reserve) results in a 13,000 m^2 wetland required upstream of the site outfall. As detailed in Figure 3, a wetland system of this size can be placed in the reserve site without the loss of any trees due to wetland construction.

Additional upstream WSUD initiatives such as tanks for toilet flushing and wet sump vortex GPT’s upstream of the bubble up pits would reduce the wetland system size further.