# Casey Planning Scheme Amendment C228

Expert Witness report provided to Planning Panels Victoria

Drainage Evidence

Prepared for the Victorian Planning Authority

Prepared by Jonathon McLean

April 2018

# 1 Witness Details

I, Jonathon McLean of Alluvium Consulting Australia (Alluvium), 105 – 115 Dover Street, Cremorne, Victoria 3121, prepared this report. I hold the position of Senior Consultant.

I have a Bachelor of Engineering (Civil) from Monash University 1990, Graduate Diploma Water Resources and Environmental Engineering Monash University 1994, Graduate Diploma MBA Program Technology Management APESMA Deakin University 2001.

I am a member of the River Basin Management Society (RBMS) and a former 10 year committee member of the Victorian Stormwater Industry Association (2001-2010).

My major fields of expertise and interest are hydrology, hydraulics, urban drainage, catchment planning and management, flood estimation, surface water modelling, stormwater treatment and waterway management.

Related Experience:

- Over a period of 20 years I have regularly been involved with the design and strategic planning of drainage strategies and systems within residential, commercial and industrial developments.
- My expert advice has been sought by both the private sector (eg developers) and the public sector (catchment management authorities and local government).
- I have been actively involved in the development of the Best Practice Environmental Guidelines for Urban Stormwater
- I have been a key contributor to the preparation of best practice guidelines for waterways and threatened species.
- I provide hydrology advice to agencies such as Melbourne Water and the Department of Environment, Land, Water and Planning (DELWP) to assist with technical guidelines to deliver appropriate habitat designs for threatened species such as Growling Grass Frogs and Dwarf Galaxias.
- I have attended and presented at various industry conferences and seminars.
- I have a sound understanding of the role of Local Government, Catchment Management Authorities, Department of Environment Land Water and Planning, and other agencies in stormwater planning and management.

Therefore my expertise and experience in flood modelling and urban stormwater management associated with civil engineering and development projects, qualifies me to make this report.

# 2 Instructions

Alluvium is currently providing stormwater management advice to Melbourne Water regarding the "functional design of wetland systems and outfalls into the Cardinia Creek in the Minta Farm Precinct Structure Plan". This work is on-going with the objective of all proposed assets to be designed to minimise impacts to environmentally sensitive parts of the Cardinia Creek and existing ponds, which currently provide important habitat for fauna species that are either of state or national significance.

I have been instructed by Thomas Patereskos from Harwood Andrews to provide expert evidence advice on the drainage issues related to the exhibited Minta Farm Precinct Structure Plan (PSP) taking into account:

- the exhibited C207 and C208 documents, background reports and submissions

In particular I have been briefed to specifically address the following issues:

- provide a summary of the preferred drainage strategy and functional design of required drainage and environmental assets for the exhibited Minta Farm PSP area

- consider the submissions made to the Amendment including any drainage components of the Minta City Proposal.

This evidence report responds directly to the above issues by providing a summary of the investigations, assumptions and assessments that have been undertaken in defining the propose drainage strategy.

# 3 Information / Documentation

In preparing this evidence Jonathon McLean has had regard to:

*Reports:*

- PSP 11 Minta Farm Precinct Structure Plan – VPA (Public exhibition October 2017)
- Background report prepared by VPA (October 2017).
- “Minta Farm PSP Surface Water Management Strategy” prepared Engeny (October 2017)
- “Input into the Minta Farm Drainage Strategy” prepared by Biosis (November 2017)
- “Preliminary review of the Minta Farm water dams” prepared by Newman Engineering (December 2017)
- “Geotechnical investigation, Minta Farm wetlands” prepared by AS James (October 2017)
- Drainage Strategy for the Overall Cardinia Creek Catchment (Stormy Water Solutions & Craigie & Condina, 2012

*Other Information:*

- Melbourne Water’s Clyde North DSS 1310 Scheme plan
- Site Inspections
- Aerial Photography
- Constructed Waterways in New Urban Developments – Melbourne Water (2013)
- Australian Rainfall & Runoff (1997) – Engineers Australia
- Urban Stormwater Best Practice Environmental Management Guidelines (1999)
- Melbourne Water’s *“Design, Construction and Establishment of Constructed Wetlands: Design Manual (Draft, 2016)”;*
- Melbourne Water’s document titled *“Principles for Provision of Waterway and Drainage Services for Urban Growth (2003)”;*
- Melbourne Water’s *“MUSIC Guidelines (2016)”;*
- DELWP’s “*Growling Grass Frog Habitat Design Standards – Melbourne Strategic Assessment (2017)”*.

Jonathon McLean adopts this evidence as a true and correct statement of his opinions and the facts he believes to be true in this matter.

# 4 Facts, Matters and Assumptions

This report is based upon an assessment and review of the information provided to me as referenced in Section 3 and the numerous site visits undertaken. During my role as project manager for the Alluvium team in undertaking investigations for Melbourne Water, I have commissioned Biosis and Newman Engineering to provide specific expert advice regarding ecology and dam engineering respectively. The reports from Biosis and Newman Engineering are included as an attachment to my evidence report. I have relied upon the recommendations and advice provided by Biosis and Newman Engineering to inform an appropriate drainage strategy.

The Minta Farm PSP area covers 286ha. A key feature of the site is a series of large waterbodies originally constructed as farm dams adjacent to the Cardinia Creek floodplain some 60 years ago. The water bodies were constructed via a combination of excavation and the installation of an embankment between the creek and dams to impound the water. **Figure 1** shows the existing landscape and adopted nomenclature for each of the waterbodies. This naming convention for the waterbodies is used throughout my evidence report

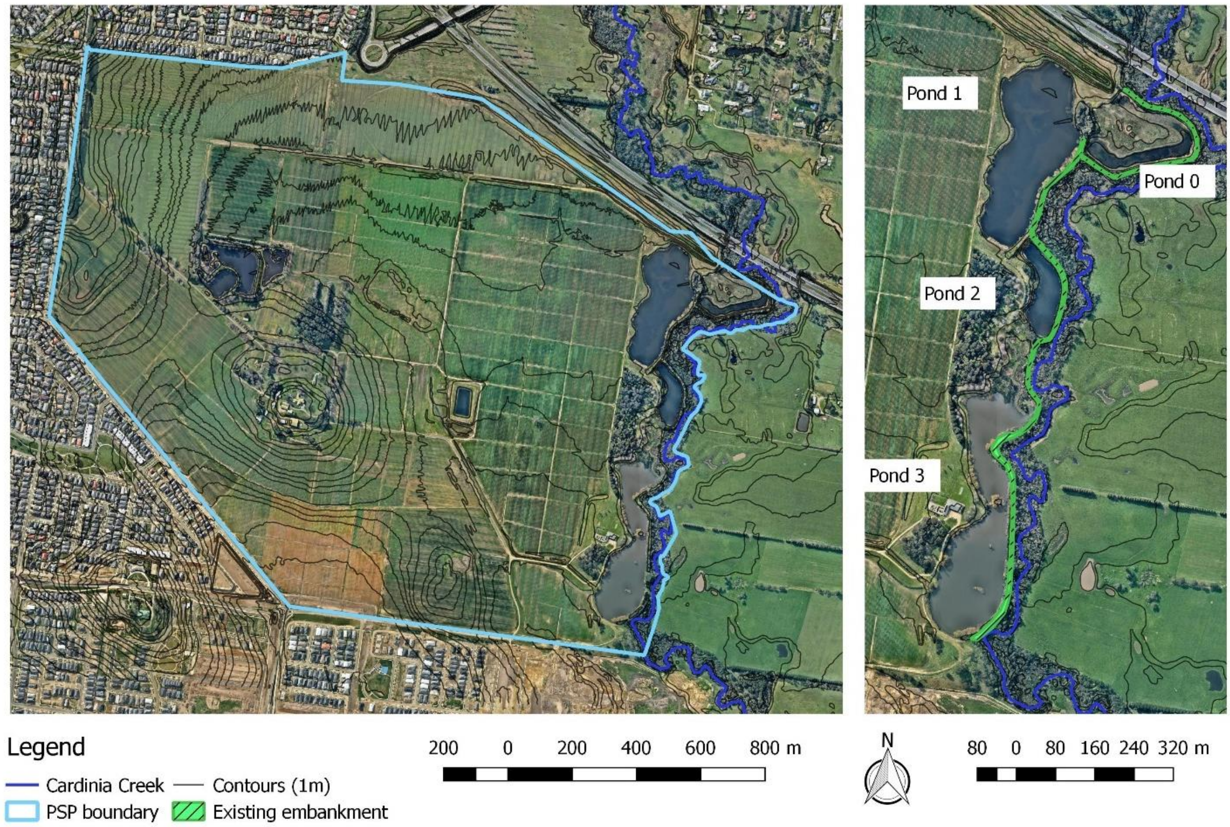



**Figure 1. Existing landscape and waterbody features within the Minta Farm PSP**

## 4.1 Stormwater Quantity – Assumptions

The following design rainfall parameters were adopted for Minta Farm based upon the Bureau of Meteorology's "Intensity Frequency Duration (IFD) Tool – AR&R 87).

**Table 1: AR&R Design Rainfall parameters (Minta Farm)**

| Parameter | Value |
|---|---|
| 1hr 2yr | 17.68 |
| 12hr 2yr | 3.94 |

| | |
|---|---|
| 72hr 2yr | 1.15 |
| 1hr 50yr | 34.02 |
| 12hr 50yr | 7.59 |
| 72hr 50yr | 2.20 |
| Skew | 0.38 |
| F2 | 4.27 |
| F50 | 14.97 |
| Zone | 1 |

The hydrologic model (RORB) was utilised for the catchment analysis and constructed waterway assessment. The following rainfall loss models were adopted.

**Table 3: Adopted RORB parameters**

| | |
|---|---|
| **Rainfall station** | Minta Farm |
| **Initial loss** | 10 mm |
| **Runoff Coefficient (100yr)** | 0.60 |
| *Interstation area above Inlet Pond 3* | |
| **m** | 0.8 |
| **kc** | 2.25 |
| *Interstation area above Inlet Pond 1* | |
| **m** | 0.8 |
| **kc** | 1.06 |

To reflect ultimate development conditions the pre-developed scenario was modified to reflect post development conditions. To understand the hydrologic impacts, the following standard Melbourne Water fraction impervious values were used as a guide (Figure 2).

Local scale sub-catchment flows have been estimated using the rational method in accordance with Melbourne Water's "Land Development Manual" and the GAA's (now VPA) "Engineering Design and Construction Manual for Subdivision in Growth Areas".

| Zone | Zone Code | Brief Description / Examples | Normal Range | Typical Value |
|---|---|---|---|---|
| **Residential Zones:** | | | | |
| Residential Growth Zone, General Residential Zone and Neighbourhood Residential Zone | RGZ, GRZ & NRZ | Large Residential. (Allotment size 601m$^2$ – 1000m$^2$) | 0.50 – 0.80 | 0.60 |
| | | Standard densities. (Allotment size 300m$^2$ – 600m$^2$) | 0.70 – 0.80 | 0.75 |
| | | High densities. (Allotment size <300m$^2$) | 0.80 – 0.95 | 0.85 |
| Low Density Residential Zone | LDRZ | Allotment size >1001m$^2$ | 0.10 – 0.30 | 0.20 |
| Mixed Use Zone | MUZ | Mix of residential, commercial, industrial and hospitals. | 0.6 – 0.90 | 0.75 |
| Township Zone | TZ | Small townships with no specific zoning structures | 0.40 – 0.70 | 0.55 |
| **Industrial Zones** | | | | |
| Industrial 1 Zone | IN1Z | Main zone to be applied in most industrial areas | 0.70 – 0.95 | 0.90 |
| Industrial 2 Zone | IN2Z | Large industrial zones away from residential areas | 0.70 – 0.95 | 0.90 |
| Industrial 3 Zone | IN3Z | Buffer between Zone 1 and Zone 3 | 0.70 – 0.95 | 0.90 |
| | | - for garden suppliers/nurseries | 0.30 – 0.60 | 0.50 |
| | | - for quarries | 0.10 – 0.30 | 0.20 |
| **Commercial Zones** | | | | |
| Commercial 1 Zone | C1Z | Main zone to be applied in most commercial areas | 0.70 – 0.95 | 0.90 |
| Commercial 2 Zone | C2Z | Offices, manufacturing industries and associated uses | 0.70 – 0.95 | 0.90 |
| **Rural Zones** | | | | |
| Rural Zone | RUZ | Main zone to be applied in most rural areas | 0.05 – 0.20 | 0.10 |
| Rural Living Zone | RLZ | Predominantly residential use in rural areas | 0.10 – 0.30 | 0.20 |
| **Public Land Zones:** | | | | |
| Public Use Zone | | | | |
| - Education | PU2Z | - schools and universities | 0.60 – 0.80 | 0.70 |

| | | | | |
|---|---|---|---|---|
| - Service and Utility | PU1Z | power lines, pipe tracks and retarding basins | 0.00 – 0.10 | 0.05 |
| | | - reservoirs | 0.40 – 0.60 | 0.50 |
| - Health and community | PU3Z | - hospitals | 0.80 – 0.90 | 0.85 |
| - Transport | PU4Z | - railways and tramways | 0.60 – 0.80 | 0.70 |
| - Cemetery/ Crematorium | PU5Z | - cemeteries and crematoriums | 0.50 – 0.70 | 0.60 |
| Local Government | PU6Z | - Libraries, sports complexes and offices/depots. | 0.50 – 0.90 | 0.70 |
| - Other Public Use | PU7Z | - Museums | 0.50 – 0.80 | 0.60 |
| Public Park and Recreation Zone | PPRZ | Main zone for public open space, incl golf courses. | 0.00 – 0.20 | 0.10 |
| Public Conservation and Resource Zone | PCRZ | Protection of natural environment or resources | 0.00 – 0.05 | 0.00 |

**Figure 2: Fraction impervious values for various land uses**

## 4.2 Stormwater Quality – Assumptions

In accordance with Melbourne Water's MUSIC Guidelines and to be consistent with the Melbourne Water's scheme approach, Narre Warren rainfall station was used with a 10-year rainfall simulation template between the years of 1984-1993.

## 4.3 Water Balance Modelling – Assumptions

Several assumptions for model parameters, structure and choice of key inputs were required, laid out below:

- Daily rainfall inputs from the Berwick gauge at Buchanan Road (June 2004 to September 2017)
    - Daily inputs were considered acceptable as the model was used as a water balance and not for water quality modelling
- Diversions and bypasses were sized in MUSIC based on a flood frequency analysis of the daily total flows, rather than estimated instantaneous peak flows
    - Peak flows are not adequately represented by the daily time step used in modelling, however are not important for water balance modelling. However, preserving the relationships between recurrence interval and quantity of water for bypasses was important as it determines the volume of water entering the ponds
- Pond storage begins at approximately 75% capacity
    - Initial conditions were tested and found not to impact the result after allowing a warm-up period of approximately one year
- Alluvium previously calibrated a MUSIC rainfall-runoff model using gauged data for a nearby catchment in Narre Warren, over a very similar flow period. The calibrated parameters from this model were used as an initial input to the Minta Farm model as they are considered more representative given the temporal and spatial proximity of the two catchments, rather than default MUSIC parameters for all of Melbourne

All other MUSIC modelling parameters and structure were selected in accordance with observed physical connections and catchment interactions.

# 5 Review of Exhibited Minta Farm PSP

The site is proposed to be developed in line with the Minta Farm Precinct Structure Plan (PSP), incorporating large areas of new residential developments and office and technology zones. The exhibited PSP is shown in Figure 4. The exhibited PSP has essentially been informed by the drainage strategy that was prepared by Engeny (Oct 2017) on behalf of the VPA and is shown in Figure 5.

In my opinion the drainage strategy for Minta Farm needs to consider, address and respond to the following key pillars as shown in Figure 3.

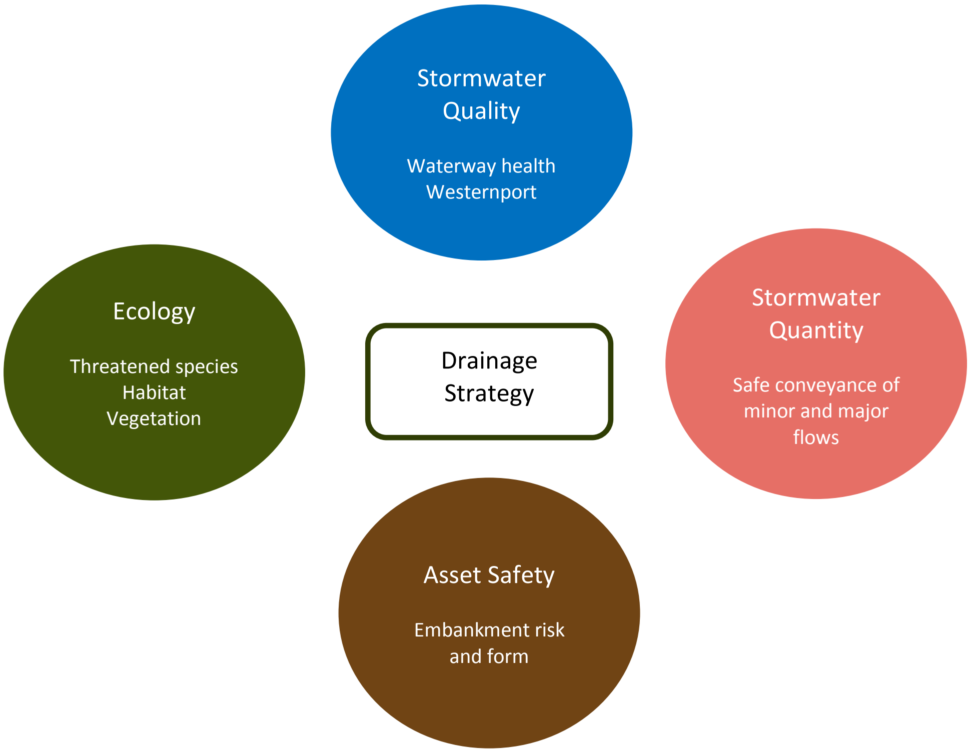



**Figure 3: Drainage considerations for Minta Farm PSP**

I have reviewed the strategy and the key issues are as follows:

- The interface and impact of the future urban drainage outfalls into the existing lakes/ponds and BCS corridor has not been addressed. This also included the connections and outfalls to Cardinia Creek. Consideration and understanding of the impacts of urbanisation on the existing environmental values is required through an eco-hydrology (e.g. seasonality) assessment.

- An external catchment area of around 50 ha north of the PSP has been diverted into the drainage system. Under current conditions the minor drainage pipe flows outfall east to the Cardinia Creek, whilst some overland flows in large rainfall events will travel south and into the PSP area. Diverting this extra catchment area transfers additional hydrologic and pollutant load into the Minta Farm PSP that needs to be managed. This potentially puts additional strain on the sensitive ecological areas along and adjacent to Cardinia Creek. Pond 1 is proposed to be converted to a constructed stormwater treatment wetland, however the maximise available size (within the nominated PSP reserve) for a wetland is 3.5 ha. Including the additional 50 ha external catchment results in additional drainage reserve land for stormwater treatment within the PSP area. From a financial perspective this additional treatment for external land would not be funded by the PSP landowners but would therefore need to be funded by Melbourne Water. Given that Melbourne Water's preferred option is for a drainage strategy and not a scheme, this may pose some difficulties to administer.

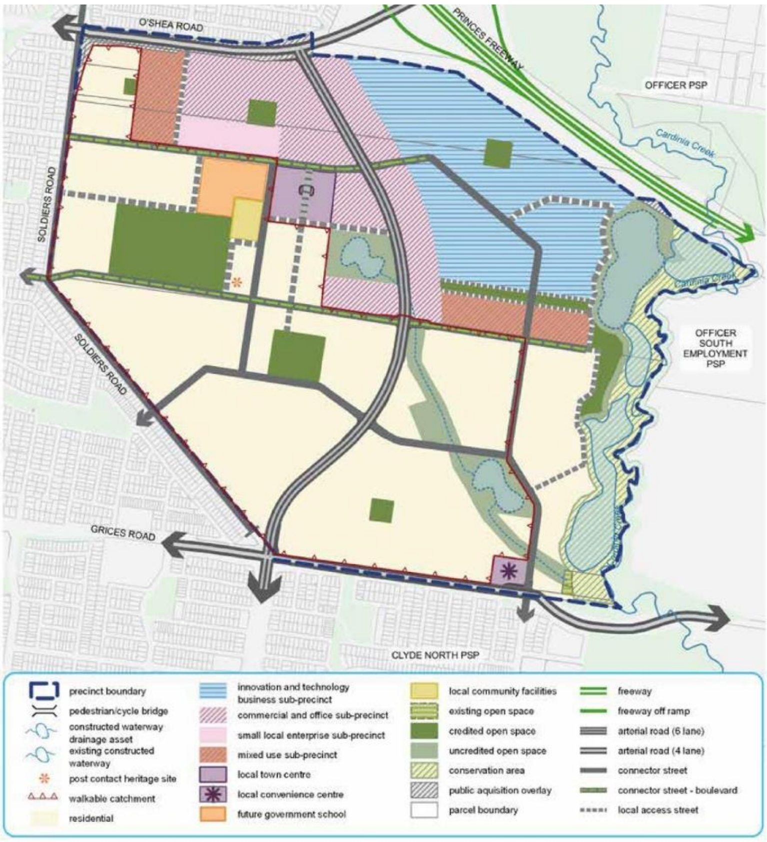



**Figure 4: Exhibited Minta Farm PSP**

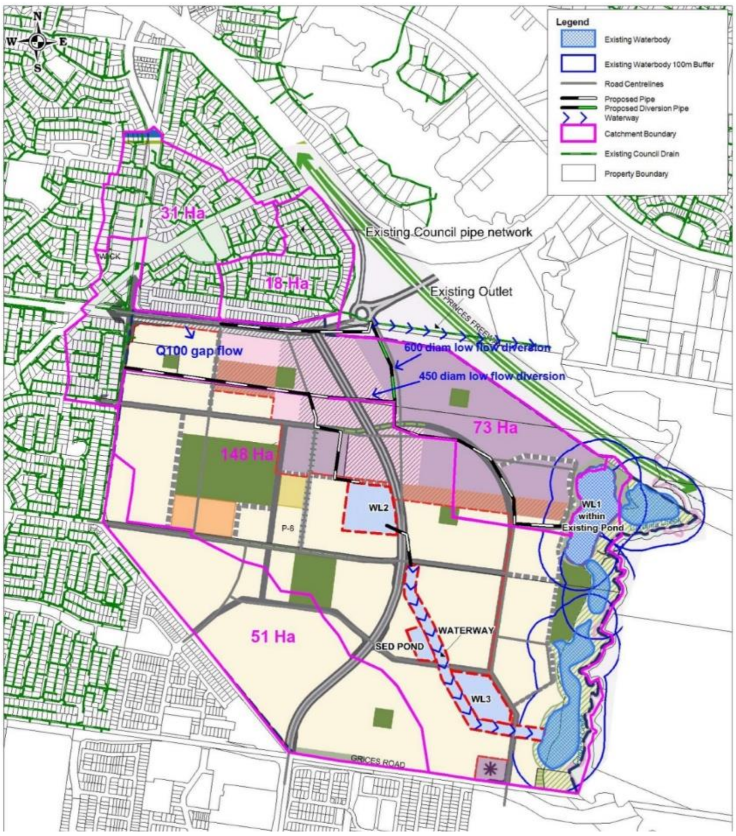



**Figure 5: Background drainage strategy plan (Engeny, 2017) that informed the exhibited PSP**

- The conversion of Pond 1 to a constructed treatment wetland does not address how flows interact with Pond 0, which has been identified by Biosis (see Section 6) as high value habitat for retention. The seasonality and ephemeral characteristics of this habitat area is important.
- Treatment wetland WL3 is located some distance to the west of Pond 3. Due to topography it may be difficult to drain all of the urban area to the east into the wetland. The outfall from WL3 is shown to only discharge to the lower end of the Pond 3, which is problematic in trying to manage the different seasonal hydrologic regime that the northern (shallow/ephemeral) and southern area require for habitat purposes (see Section 6). The location of WL3 does not provide the desired flexibility and adaptive management options to manage the hydrologic regimes to different zones.
- The condition of the existing pond embankments and their long term viability and safety have not been considered in the exhibited plan. The fate of the embankments are intrinsically linked to the drainage strategy and existing ecological values.
- The strategy for conveying overland flows through the town centre is a critical element of the drainage strategy, however this issue has not been specifically addressed

## 5.1 Recommendation

In my opinion the exhibited PSP and drainage strategy needs to be amended so that it integrates and responds to the existing site constraints and values. By its nature, implementation of the PSP and the corresponding land use change will dramatically alter the hydrologic regime that currently supports the existing habitat and ecological values. As a result it is imperative that the drainage strategy considers and integrates the needs of the following key pillars:

- stormwater quality,
- stormwater quantity,
- ecology
- safety.

Alluvium has been working collaboratively with Melbourne Water, DELWP and the VPA to develop drainage strategy scenarios that respond to the above needs. A summary of the approach and options is provided in Section 7.

As a result I recommend that the PSP be amended to reflect the alternative configuration as presented in this evidence.

# 6 Understanding the existing conditions / values

## 6.1 Hydrology

There are three distinct catchments within the Minta Farm PSP site. Two of these outfall across the site boundary and do not contribute inflows to the pond system. Of these two, the larger (approx. 55 ha) outfalls to the south-east through Melbourne Water's Ti Tree Creek Development Services Scheme (DSS), and the smaller (approx. 11 ha) falls across the southern boundary to Melbourne Water's Clyde North DSS.

The remaining site area (approx. 212 ha, less the Cardinia Creek floodplain) forms the greater catchment contributing to each of the waterbodies. An external catchment to the north-west also contributes flows to the system, eventually pond 3. The size of this catchment changes depending on the rarity of the rainfall event (and subsequent runoff response), beginning at approx. 19.6 ha for flows more common than the 18% AEP event (or 5-year ARI), and extending to 63.8 ha for rarer events, typically occurring as overland flows.

Figure 6 demonstrates the catchment spatial extent, including breakdowns for each catchment contributing to individual ponds.

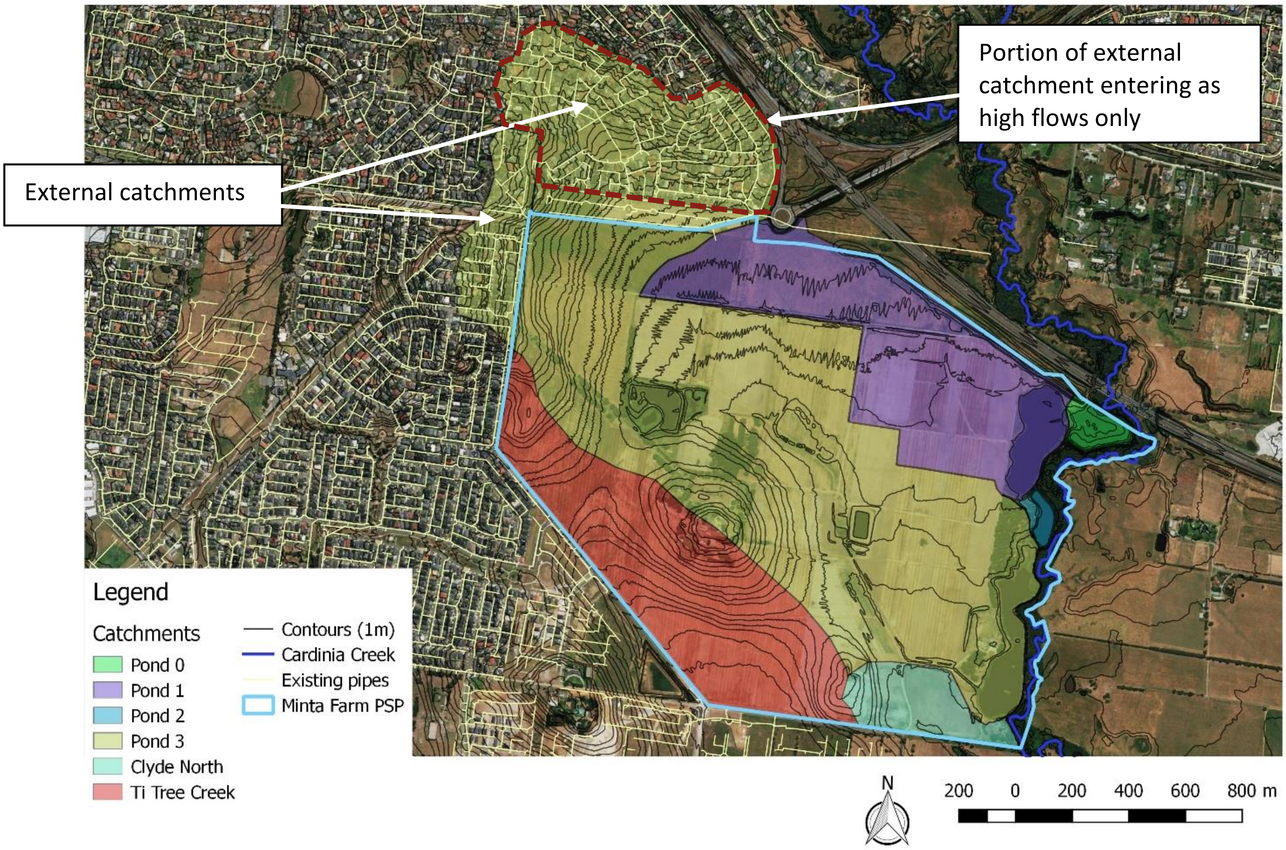



**Figure 6: Layout of catchments within the Minta Farm PSP site**

There is no hydrological connection between Cardinia Creek and the existing embankments. Currently embankment crests are well above the 1% AEP flood level in Cardinia Creek.

**Pond system interactions**

All ponds receive inflows from their contributing catchments, with major negative fluxes to evaporation and groundwater infiltration. Only ponds 1 and 3 have large contributing catchments – inputs for ponds 0 and 2 are mostly from overflows or connections from adjacent ponds or direct rainfall on the water surface.

**Current hydrologic regime**
The existing hydrologic regime was characterised through a combination of site inspection, collation of anecdotal/historical evidence and rainfall-runoff modelling. A MUSIC rainfall-runoff model was used to simulate the daily runoff response and water fluxes in each of the ponds.

Model parameters were calibrated to observed data in the form of time-stamped aerial imagery, water level information from site survey and anecdotal reports on typical ranges inter-annual variability from the current landholder who has occupied the site for several decades. Most of the "calibration" data was in the form of aerial imagery, which provided approximately 50 data points from 2009-2017 on surface area in each pond. Estimates of surface area were converted to a water level in each pond using an area-stage-storage relationship developed through bathymetric survey.

Figure 7 shows the observed time series of water levels in each pond and the associated modelled outputs for the calibrated parameter set. Overall, the model was able to replicate the timing of major peaks and troughs in storage and the variability of the observed data, and is considered a reasonable representation of system behaviour on seasonal timescales. Table 4 describes the hydrological characteristics of each pond based on the modelling results.


**Figure 7. Comparison of observed and modelled water levels in each pond**

**Table 4. Existing hydrological regime in each pond**

| Pond | Existing characteristics | Typical water level annual variability (+-) |
|---|---|---|
| **0** | Minor seasonal cycle overlaid by a major inundation and drying cycle each ~5 years. Gentle, uneven grade within the pond lead to large areas of exposed marshy/swampy zones during drying cycles | 1-1.2m |
| **1** | Seasonal variations, mostly a perennial open water body | 0.2-0.4m |
| **2** | Minor seasonal cycle overlaid by a major inundation and drying cycle each ~5 years. Steep sides make no marked change in water extent with drying cycles | 0.5-0.6m |

| | | |
|---|---|---|
| **3** | Southern portion of the pond is predominantly a perennial open water body. A higher base elevation section in the north shows strong seasonal variations in wetting/drying and exposed marshy/swampy areas. These two distinct “zones” form two separate hydrologic characteristics of pond 3. Figure 8 shows the typical extent of observed wetting and drying cycles. | 0.8-1m |


**Figure 8. Observed wetting and drying extent exposing ephemeral marsh in the northern section of pond 3**

The historical aerial imagery also demonstrated the presence of significant algal blooms in each pond, predominantly during warmer summer months. This is likely due to the very long residence times within each lake, driven by most exfiltration from the systems being gradual infiltration and evaporation (i.e., the ponds are effectively a “sink” for the local catchment). An example of observed blooms is shown in Figure 9.

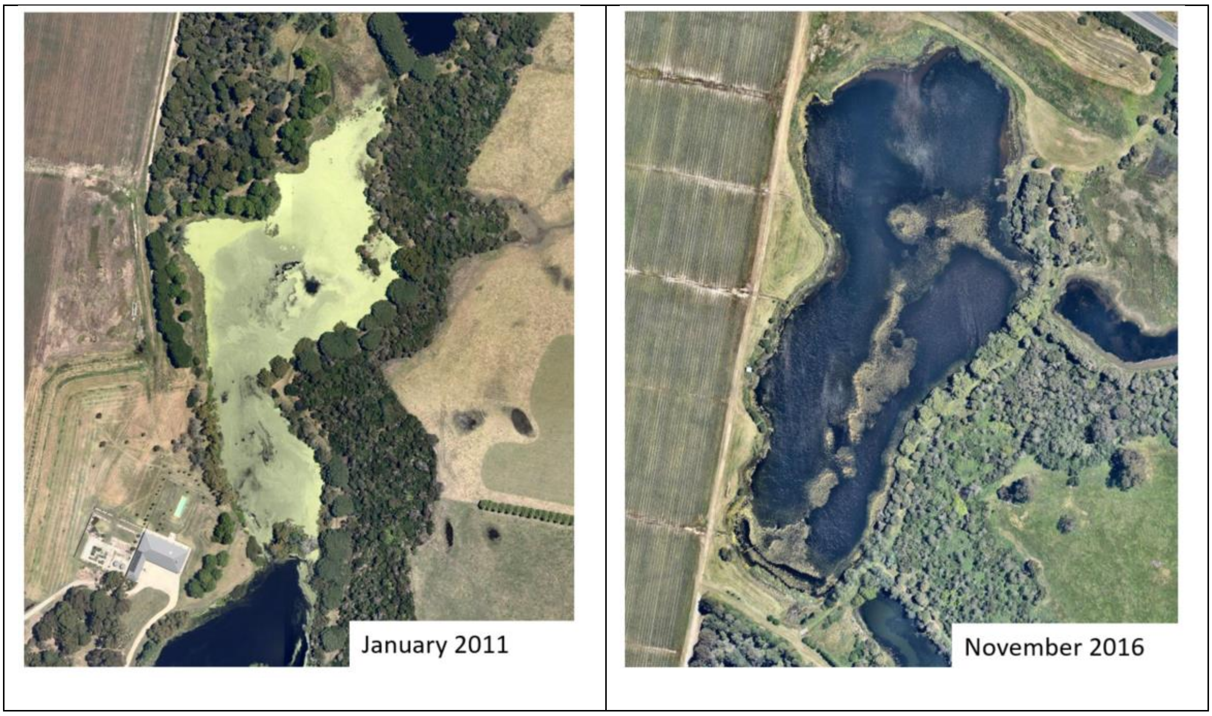



**Figure 9. Example of observed algal blooms in ponds 3 (left) and 1 (right)**

## 6.2 Ecology

The impact of development on the hydrologic regime of the existing waterbodies will affect the viability of habitat for key federally listed species Latham's Snipe, Dwarf Galaxias, Australian Grayling and the Growling Grass Frog, which are known to occupy the site or adjacent areas. In addition, the site provides extensive high-value habitat for state listed waterbirds in open, deep pools and islands. The values have been mapped and summarised in Figure 10 and Figure 11. A more comprehensive description of the ecological species assemblages and values are documented in the supporting ecology report prepared by Biosis (see Attachment).

In my opinion the key findings of the ecological study are:

- Maintain hydrological regime in Pond 0.
- Retain the current hydrological regime in Pond 3 (areas of permanent open water for foraging and breeding habitat for threatened duck species).
- Retain the breeding waterbird islands within Pond 3.
- Retain and enhance Dwarf Galaxias habitat (key location of interest is shown in Appendix F).
- Develop at least some wetlands to include key Growling Grass Frog wetland habitat
- Maintain and enhance shallow areas within existing wetlands and create new shallow, well-vegetated wetlands.

**Key ecological attributes to maintain:**

- Large, deep (>1.5m) waterbodies which is preferred habitat for threatened ducks (Hardhead, Musk Duck, Freckled Duck, Australasian Shoveler) and other species including fish-feeding birds (e.g. cormorants)
- The islands in Pond 3
- To the fullest extent practicable, minimise disturbance to any native vegetation in the vicinity of Cardinia Creek especially within BCS Conservation Area 36
- Shallow and or ephemeral wetlands (e.g. Pond 0 and shallow northern end of Pond 3, which provide habitat for Latham's Snipe and egrets and provide excellent frog breeding habitat
- Cardinia Creek, especially anabranches which provide important habitat for Dwarf Galaxias.

**Key ecological attributes to enhance:**

- Develop WQ treatment assets in areas identified as low-quality habitat.
- Development of one or more wetlands for GGF. In particular, investigate the opportunity to create wetlands that are not hydrologically connected to Cardinia Creek (potentially Pond 2).
- Areas of native vegetation to provide greater protection to the riparian values along Cardinia Creek.
- Smaller wetlands with connectivity to Cardinia Creek that should be planted with shade-casting shrubs such as Swamp Paperbark, to act as potential refuge habitat for Dwarf Galaxias.
- Wetlands (including stormwater treatment assets) or parts of wetlands with extensive areas of well-vegetation shallow water (<0.5m deep) and areas of exposed mud to provide Latham's Snipe habitat.


**Figure 10. Existing ecological values**

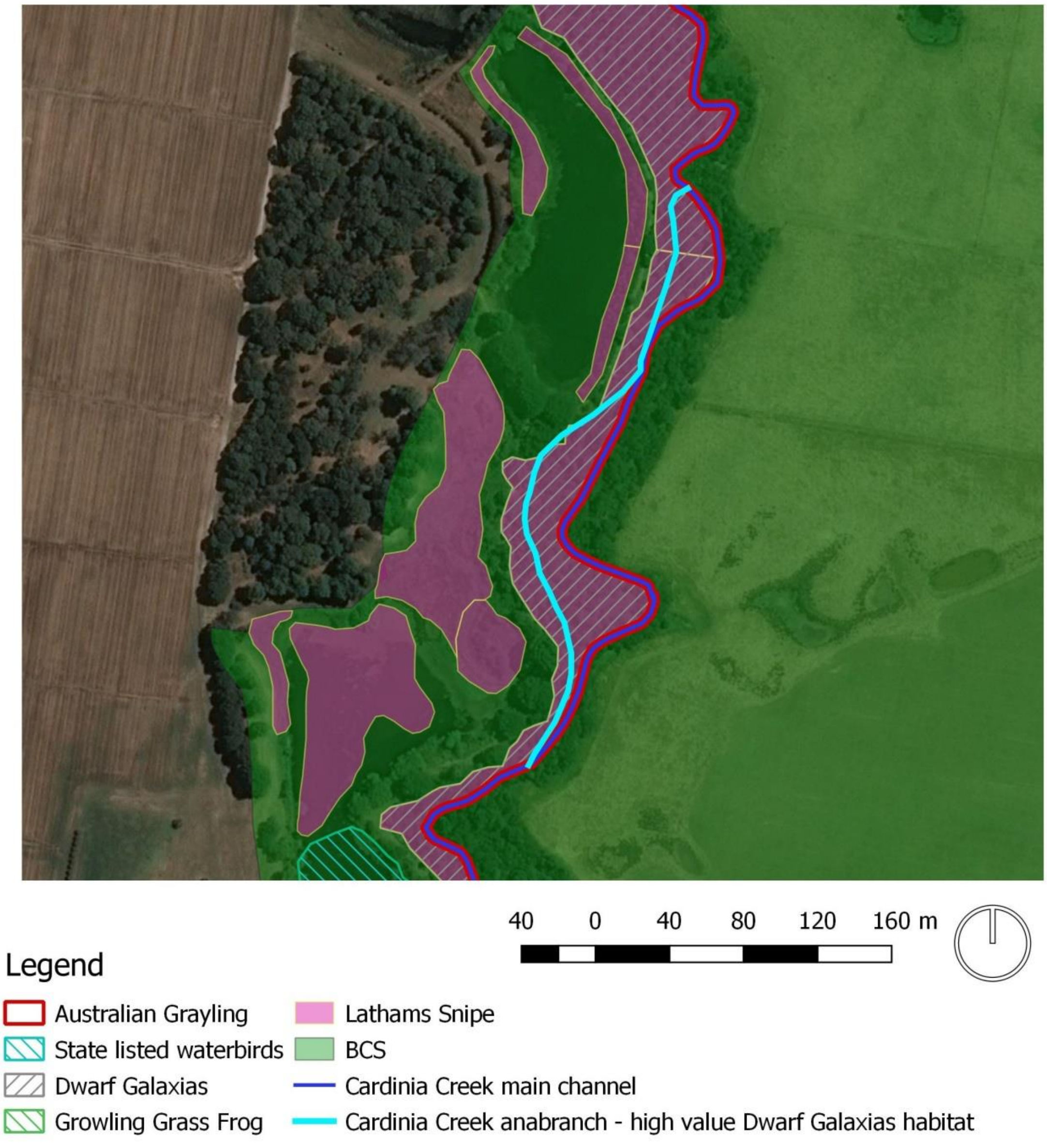



**Figure 11. "Zoomed in" mapping of dwarf galaxias high value anabranch**

## 6.3 Pond embankments

Each waterbody relies on an embankment for storage as a disconnection from the Cardinia Creek floodplain. A preliminary geotechnical investigation was carried out by AS James (see attachment) via site inspection and subsurface investigation on sampled material from four boreholes.

Newman Engineering, who are dam integrity specialists, undertook a stability and integrity assessment of the existing embankments. In summary the investigations determined that the embankments are in generally poor condition, having been informally constructed 60 years ago with little compaction. They are situated on weak organic foundations with possible sandy lenses, with large trees growing directly on steep batters and are 4-5m high in some places.

Newman Engineering identified that "*it is likely in a formalised risk assessment process there would be elevated risks associated with a number of failure modes including stability and piping. The reality with an old embankment such as at Minta Farm is that the embankments could not be relied on as part of a new development. The design and construction of the embankment some 60 years ago is not consistent with current standards and Melbourne Water requirements. In addition, given the on-going development of the downstream catchment there will likely be increasing population at risk as time progresses. This results in at least a Significant or High ANCOLD risk consequence category".*

Based the investigations by Newman Engineering, it is difficult to envisage any embankment being considered acceptable without being fully reconstructed or retrofitted with filters. Therefore works on the embankment, and therefore some degree of ecological disturbance, is unavoidable based upon safety grounds.

# 7 Proposed drainage strategy

## 7.1 Key principles

Based on the issues outlined in Section 5 and 6, the drainage strategy and the PSP for Minta Farm needs to go beyond the traditional approach of stormwater quantity, stormwater quality and waterway management. That is the drainage strategy also needs to respond to the challenges and constraints posed by the existing ecological values, the safety and asset management of the pond embankments and the change in catchment hydrology caused by urbanisation.

As a result the proposed drainage strategy has been informed by the following key principles.

***<u>Principle 1 - Stormwater quantity and flood management</u>***

The proposed development will dramatically increase the impervious area, and subsequently the proportion of rainfall which will become surface runoff. The drainage strategy needs to identify the size and location of overland flows paths to cater for the 1% AEP rainfall event and determine whether this can be safely conveyed within road reserves or whether a waterway corridor is required.

The Cardinia Creek is a major watercourse that naturally meanders from its source at Aura Vale Lake to just downstream of Pattersons Road where it enters the Koo-Wee-Rup Flood Protection District (KWRFPD). At this point the waterway takes the form of a straight man-made drain, with a levee on the southern side of the drain that forms the flood protection mechanism for land located to the south of Cardinia Creek in the KWRFPD. The management of the Cardinia Creek system is complex and there have been many reports that have been prepared over the last 5-6 years in relation to the potential impacts of development in the Cardinia Creek catchment. The flow management strategy for Minta Farm is proposed to align with the principles advocated in the Drainage Strategy for the Overall Cardinia Creek Catchment (Stormy Water Solutions & Craigie & Condina, 2012). It is this strategy that reviewed and consolidated all of the previous investigations and provided recommendations for a catchment wide strategy from new development within the Cardinia Creek Catchment south of the Pakenham Bypass. This work considered the impacts of peak flow, volumes and levees on the KWRFPD and the most effective and appropriate approaches for managing flows. A key finding that affects the Minta Farm PSP area is that no flow mitigation is needed to manage run-off in large events up to and including the 1% AEP event. The airspace above wetland systems will provide storage capacity to offset the impacts on peak flows for smaller flood events (up to the 2 year ARI event). An implied recommendation was that the use of constructed treatment wetlands will be the most appropriate and efficient way of treating storm water quality and quantity within the Cardinia Creek catchment.

In summary the key criteria are:

- No retarding basins are required within the Minta Farm PSP
- Flood mitigation works will be required at the Cardinia Creek Outfall (downstream of McCormacks Road) to ensure the 1% AEP flow is maintained within the leveed outfall and there are no increased flood effects within the KWRFPD.
- Flow management for ecological protection (e.g. 1.5 year ARI) should be provided. It is expected that this attenuation could be provided as a “by-product” to constructing wetlands for stormwater quality treatment.
- Overland flow paths within the Minta Farm PSP to safely convey the 1% AEP flows.

***<u>Principle 2 - Stormwater quality and load reduction to receiving waters</u>***

In order to meet the receiving water requirements associated with the State Environmental Protection Policy (SEPP), stormwater runoff from urban development is expected to achieve “best practice” treatment. In general these best practice pollutant reduction targets are considered to be:

- 80% reduction in total Suspended Solids loads
- 45% reduction in total Nitrogen loads
- 45% reduction in total Phosphorus loads

The above targets are based upon meeting the requirements of SEPP Schedule F7, which relates to the Yarra and Port Phillip Bay catchment. However for Western Port Bay, it is necessary to comply with the SEPP Schedule F8 water quality targets. Following a recent review by Melbourne Water, DELWP and EPA the following best practice load reduction targets are required for Western Port.

- 85% reduction in total Suspended Solids loads
- 45% reduction in total Nitrogen loads
- 45% reduction in total Phosphorus loads

***Principle 3 - Ecological protection and enhancement***

The impact on the existing ecological values needs to be minimised whilst the opportunity for enhancement should be considered to lessen the overall impact from the PSP development. In summary the key criteria are:

- Maintain hydrological regime in Pond 0 to support Latham Snipe and the Growling Grass Frog.
- Retain the current hydrological regime in Pond 3 (areas of permanent open water for foraging and breeding habitat for state listed waterbirds).
- Retain the breeding waterbird islands within Pond 3.
- Retain and enhance Dwarf Galaxias habitat
- Develop at least some wetlands to include key Growling Grass Frog wetland habitat
- Maintain and enhance shallow areas within existing wetlands and create new shallow, well-vegetated wetlands.
- Minimise disturbance to existing swamp scrub by minimising works between the toe of the existing embankment and Cardinia Creek

***Principle 4 - Resilient and adaptive assets to optimise urban hydrology***

Development within the Minta Farm PSP will lead to substantial hydrological changes. These changes have the potential to adversely affect existing ecological values and change the risk profile of the established embankments. The hydrological effect of development was simulated through a long term water balance model to reflect proposed development within the Minta Farm PSP.

Figure 12 shows the modelled pond water levels for the same period of rainfall inputs as the existing conditions model. Substantial changes are evident in the hydrologic regime, mostly as a result of increased runoff from a higher fraction of impervious surfaces within the catchment. Much of the inter-annual variability in each pond is reduced after development. Table 5 describes the new hydrologic regime for each individual pond.

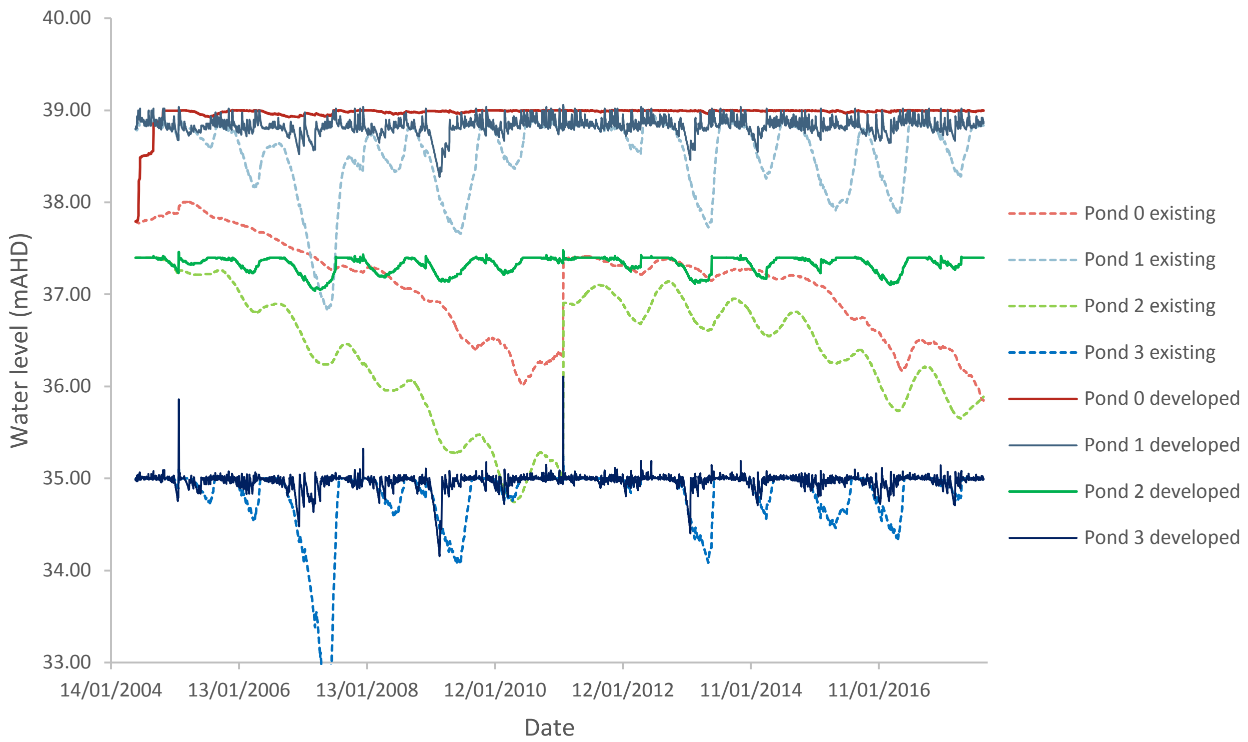



**Figure 12. Comparison of modelled pre-developed and developed water levels in each pond**

**Table 5. Changes in the hydrologic regime for each pond as a consequence of development**

| Pond | Changes to hydrologic regime | Typical water level annual variability (+-) |
|---|---|---|
| **0** | Completely full, almost no variability in levels throughout the year. All seasonality and ephemerality are eliminated. In comparison under existing conditions the pond only fills irregularly (eg once every five years or so) and slowly empties where it can be dry for many years. | 0-0.1m |
| **1** | High frequency variation, no gradual seasonal trends | 0.2-0.4m |
| **2** | Some seasonal variation, no major drying/inundation cycles. | 0.2-0.3m |
| **3** | High frequency variation, reduced seasonal trends. Northern marsh zone is almost permanently inundated, removing the previous “dual-zone” regime in the northern and southern sections. Southern section remains at high water levels. Presence of high water levels leads to increased incidence of flooding (i.e. pond loses its natural storage effect). | 0.3-0.5m |

These changes are further highlighted for pond 3 in Figure 13 showing the change (or virtual elimination, left) in seasonal variations and much higher frequency of inundation (right).

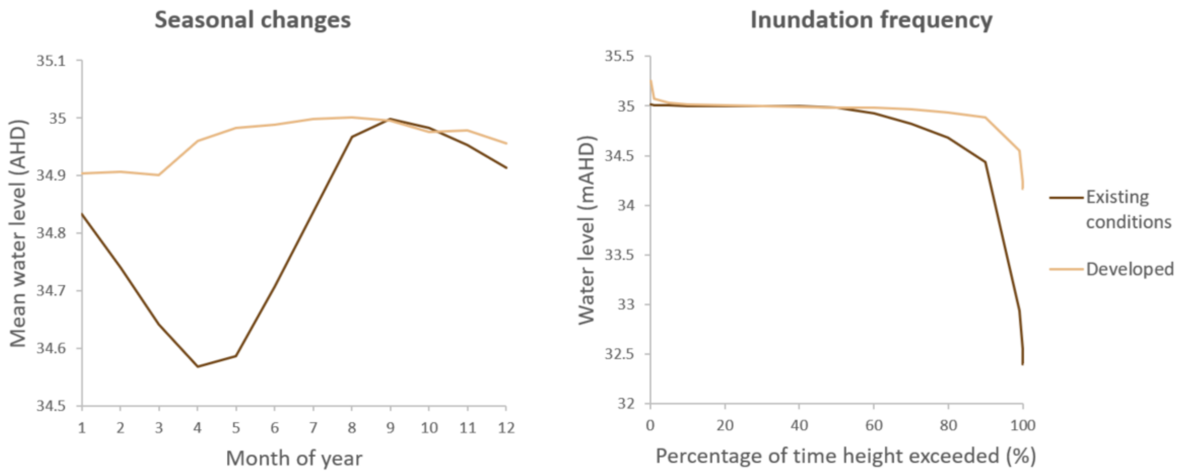



**Figure 13. Left panel: changes in average seasonal variations, right panel: increased inundation frequency**

These changes would impact existing high value habitat for key species within the site, particularly the ephemeral marsh/swamp in pond 0 and the north of pond 3 which currently supports breeding and feeding habitat for Latham's Snipe and frog species.

As a result the drainage strategy needs to have the flexibility to adapt to the hydrologic needs of the key habitat needs. This could be achieved by:

- locating stormwater treatment assets adjacent to the key habitat areas and providing release or spills at different heights and frequency. For example wetland WL3 could be sighted adjacent to Pond 3 to provide low flow discharges to support a regular full supply level in open water zones, whilst a less frequent high level spill from the wetland could engage with the northern section of pond 3 to support its ephemeral and seasonal characteristics.
- the use of valves or penstocks to allow the manual release of flows into key ecological areas.

***<u>Principle 5 - Embankment safety</u>***

The existing embankments are in poor condition and pose a long term safety risk. As a result the embankments cannot remain in its existing form and will need to either:

- Decommissioned
- Rebuilt
- Remediated

As a result there will be some ecological disturbance. Therefore the criteria is not a silver bullet or "one size fits all" approach. The drainage strategy is based on selecting the appropriate embankment approach for each individual pond.

***<u>Principle 6 – Minimise land take and integrate with urban form</u>***

Whilst principles 1 to 5 need to be achieved, the evaluation and assessment to determine the preferred drainage strategy option considers the overall developable land budget consumed by the drainage assets.

## 7.2 Drainage strategy options

The drainage strategy has been configured by considering the system in two phases:

- Phase 1 - The options for stormwater assets contained within the PSP
- Phase 2 - The options for the existing embankments

This approach allows an option for Phase 1 to be matched with a variety of options for Phase 2.

## 7.3 Phase 1 – options for stormwater assets

The six principles outlined in section 7.1 have been used to inform two primary options. The fundamental difference is the location and function of the constructed waterway corridor, with one option containing a "west – east waterway corridor" in the northern property and the other containing a "north – south waterway corridor" predominately within the southern property. The two primary options have therefore been named the "Option 1 : west-east waterway corridor" and the "Option 2: north-south waterway corridor".

Both option 1 and option 2 are based on the removal of the existing Baillieu residence. An alternative scenario "b" has been considered for both options which includes the retention of the Baillieu residence.

***Option 1: west-east waterway corridor***

The key features and elements of the west-east corridor are shown in Figure 14 and can be summarised as follows:

- Sediment basin SB2 treatment area of 2000m2 and drainage reserve of 1.6ha
- SB2 outflows to west-east waterway corridor
- Waterway corridor width of 60 metres and drainage reserve of 5.0ha
- Sediment basin and wetland SB1/WL1 treatment area of 3.61ha
- Low flows diverted to WL1 from the waterway corridor via a pool and riffle section
- Low flows from WL1 piped to Cardinia Creek in the north. Alignment to follow the existing track to minimise swamp scrub disturbance
- High flows (approx. 1 in 3 to 5 years) spill from WL1 to fill Pond 0
- Spillway outlet from Pond 0 to Cardinia Creel to control overtopping
- Constructed waterway outfalls to Cardinia Creek and avoids Dwarf Galaxias high value anabranch
- Sediment basin and wetland SB/WL3 treatment area of 1.317ha and drainage reserve of 4.4ha
- Low flows from WL3 enter the open water zone of Pond 3
- Earthen mound profile to separate ephemeral zone of Pond 3 from open water zone of Pond 3
- High flows from WL3 enter the ephemeral zone of Pond 3

Option 1 does not follow Melbourne Water's standard scheme approach of aligning the waterway corridor to follow the "valley floor". The impacts associated with diverting the waterway corridor "west-east" includes additional cut/depth required for the waterway (and therefore wider corridor width to accommodate), some localised filling to the north of the SB1 reserve and the use of allotment retaining walls (< 900mm) along the length of the waterway corridor. The meandering low flow waterway layout is shown in Figure 15, whilst the long-section of the waterway is shown in Figure 16.

The benefits of the waterway diversion are a reduced land take (due to a much shorter length) and potentially better ability to achieve the environmental watering regime for Pond 0. However whilst Option 1 has a lower overall cost, the location of the west-east waterway corridor is on a different land title to the natural north-south waterway corridor. Normal scheme principals do not reimburse land costs associated with waterway corridors. This presents a significant operational issue for Melbourne Water regarding "equity" with respect to a different landowner receiving the benefit to the one who bears the cost. As a result it will be necessary to seek the agreement of both landholders to ensure commercial interests are not impacted. For example this could potentially take the form of an agreement between the two parties to undertake a land swap or a monetary compensation.

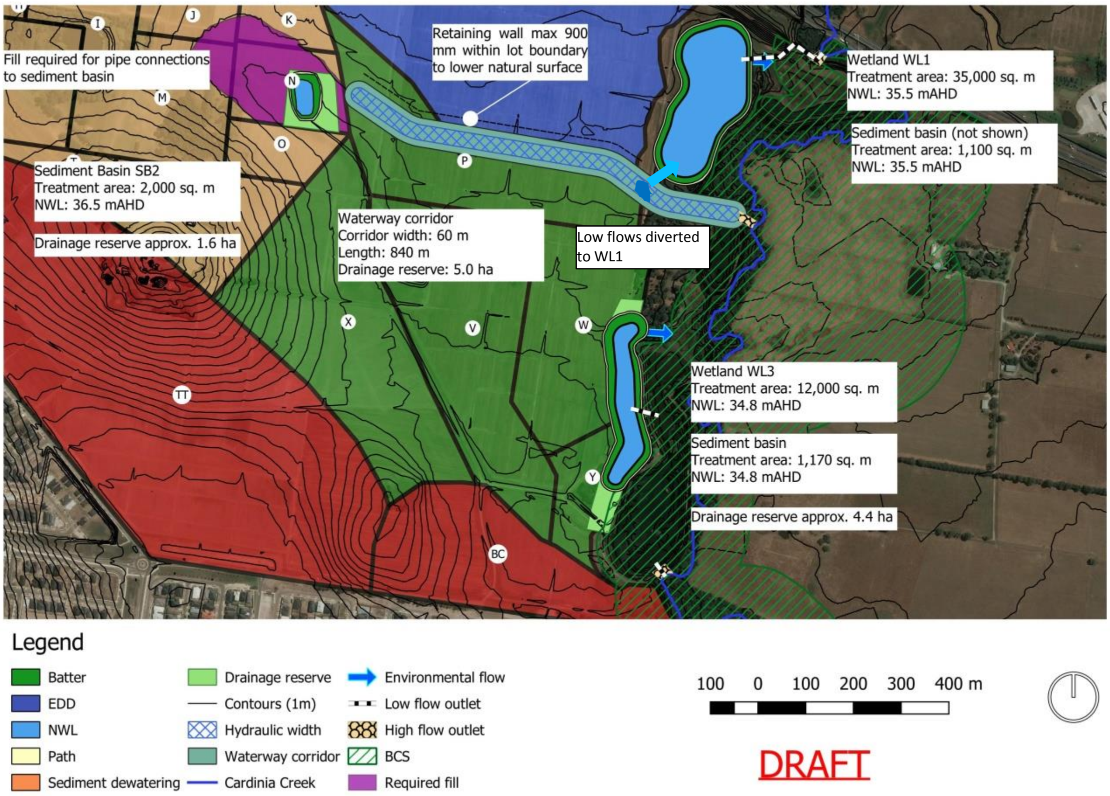



**Figure 14. Option 1: "west-east waterway corridor" layout**

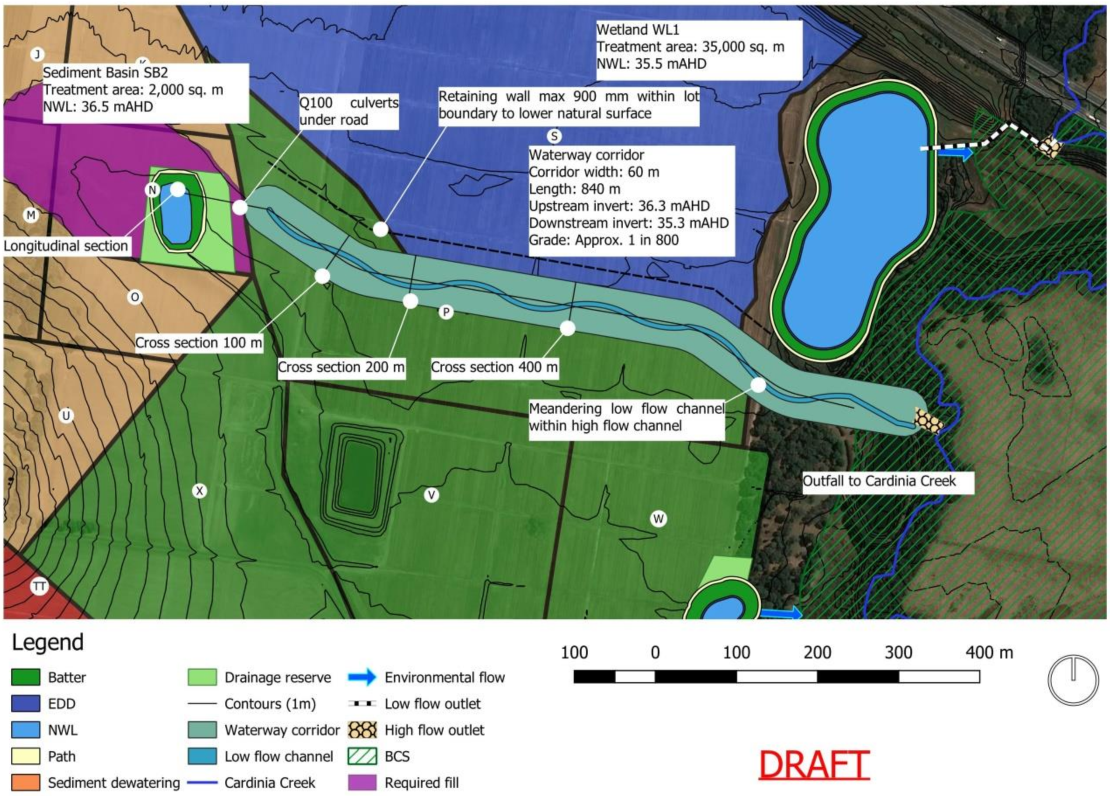



**Figure 15. Option 1: layout plan of the west-east waterway corridor**

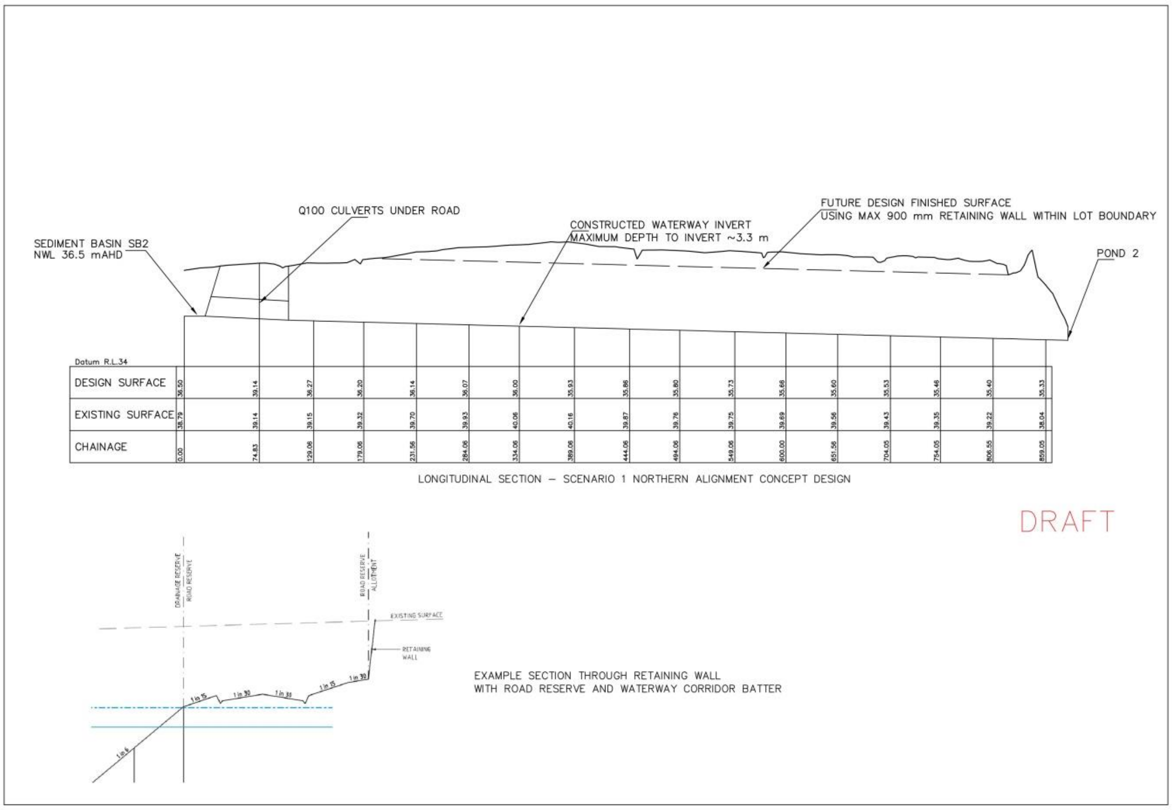



**Figure 16. Option 1: long-section of the west-eat waterway corridor**

***<u>Option 1b: west-east waterway corridor (retention of the Baillieu house)</u>***

Option 1b is similar to Option 1 however asset WL3 needs to be spilt into two separate treatment assets in order to retain the existing house (refer to Figure 17). The reconfiguration of WL3 is as follows:

- Sediment basin and wetland SB/WL3b located to the north of the house with a treatment area of 0.97ha and a drainage reserve of 3.4ha
- Sediment basin and wetland SB/WL4b located to the south of the house with a treatment area of 0.542ha and a drainage reserve of 1.8ha

Whilst option 1b retains the existing house, two treatment assets are required rather than a single consolidated asset. These additional assets will not only cost more from a capital perspective but will also cost more to maintain in the long term.

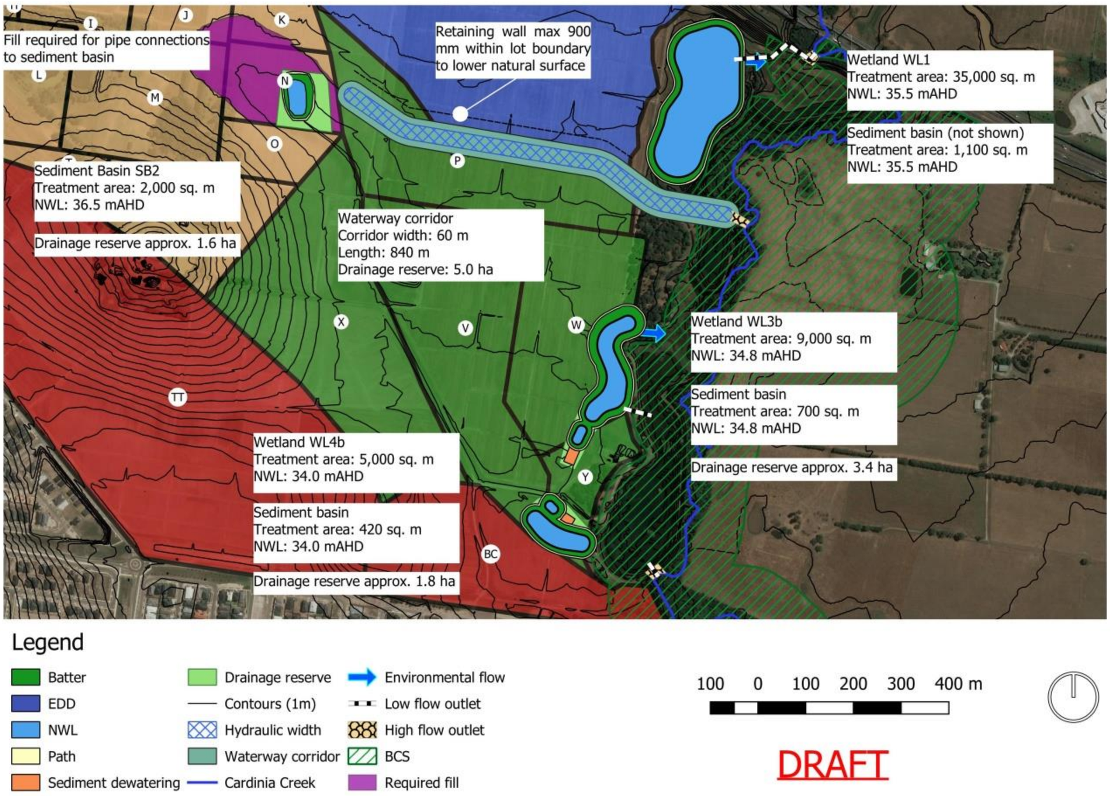



**Figure 17. Option 1b: "west-east waterway corridor" layout which retains the existing house**

***Option 2: north-south waterway corridor***

The key features and elements of the north-south waterway corridor are shown in Figure 18 and can be summarised as follows:

- Sediment basin and wetland SB/WL2 treatment area of 1.526ha and drainage reserve of 3.9ha
- WL2 outflows to north-south waterway corridor
- Waterway corridor width of 50 metres and drainage reserve of 6.8ha
- Sediment basin and wetland SB/WL1 treatment area of 3.61ha. WL1 is oversized to offset reduced pollutant load treatment from SB1 catchment
- Flows diverted to WL1 is form local catchment "S"
- Low flows from WL1 piped to Cardinia Creek in the north. Alignment to follow the existing track to minimise swamp scrub disturbance
- High flows (approx. 1 in 3 to 5 years) spill from WL1 to fill Pond 0
- Spillway outlet from Pond 0 to Cardinia Creel to control overtopping
- Constructed waterway outfalls to Cardinia Creek at a location that minimises swamp scrub disturbance
- Sediment basin SB1 treatment area of 330m2 and a drainage reserve of 0.3ha.
- Sediment basin and wetland SB/WL3 treatment area of 0.777ha and drainage reserve of 2.1ha
- Low flows from WL3 enter the open water zone of Pond 3
- Earthern mound profile to separate ephemeral zone of Pond 3 from open water zone of Pond 3
- High flows from WL3 enter the ephemeral zone of Pond 3

Option 2 follows Melbourne Water's standard DSS principals. In particular the accepted approach that a waterway corridor should follow the natural valley floor. From an asset management perspective Option 2 has one additional treatment asset (ie a sediment pond in the western side of the waterway corridor) compared to Option 1.

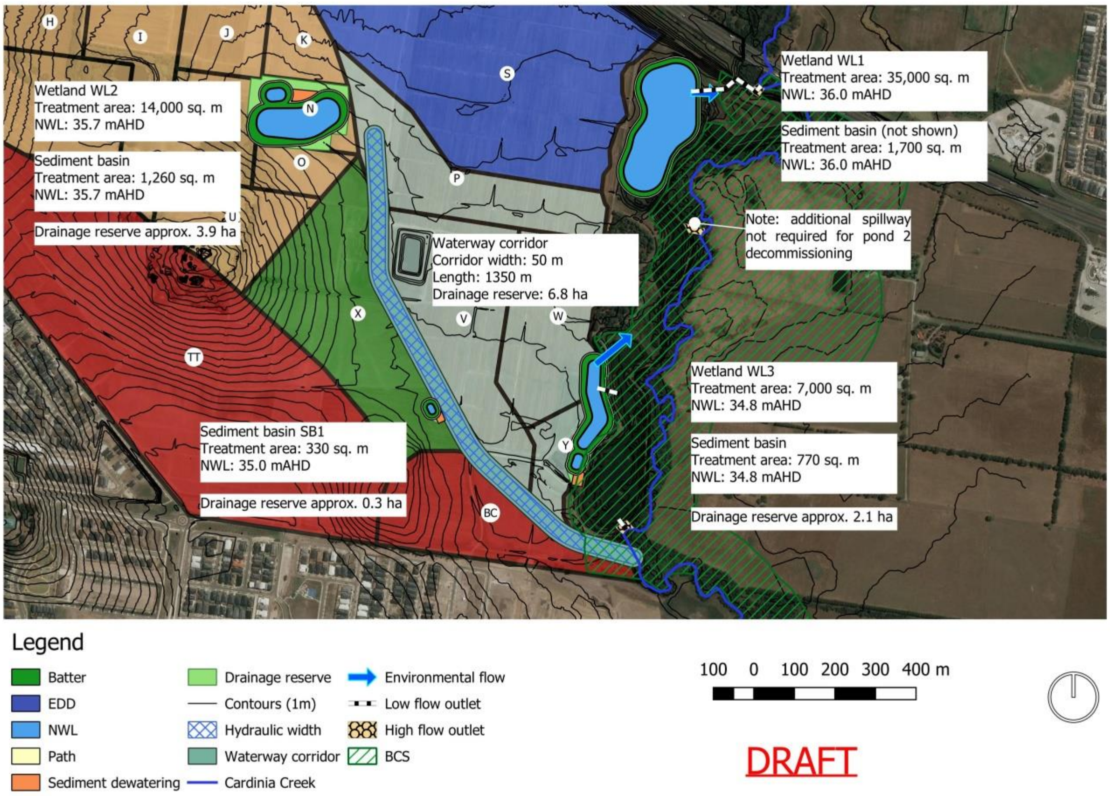



**Figure 18. Option 2: "north-south waterway corridor" layout**

***Option 2b: north-south waterway corridor (retention of the Baillieu house)***

Option 2b is similar to Option 1 however asset WL3 and SB1 needs to be configured (refer to Figure 19). That is WL3 needs to be spilt into a sediment basin/wetland north of the house and a sediment basin to the south of the house. Sediment basin SB1 is replaced with a sediment basin and wetland system. The reconfiguration is as follows:

- Sediment basin and wetland SB/WL3b located to the north of the house with a treatment area of 0.561ha and a drainage reserve of 1.6ha
- Sediment basin SB1 located to the south of the house with a treatment area of 250m2 and a drainage reserve of 0.2ha
- Sediment basin and wetland SB/WL4b located to the west of the waterway corridor with a treatment area of 0.283ha and a drainage reserve of 0.9ha

Whilst option 1b retains the existing house, and additional sediment basin and an additional wetland is required. These additional assets will not only cost more from a capital perspective but will also cost more to maintain in the long term.

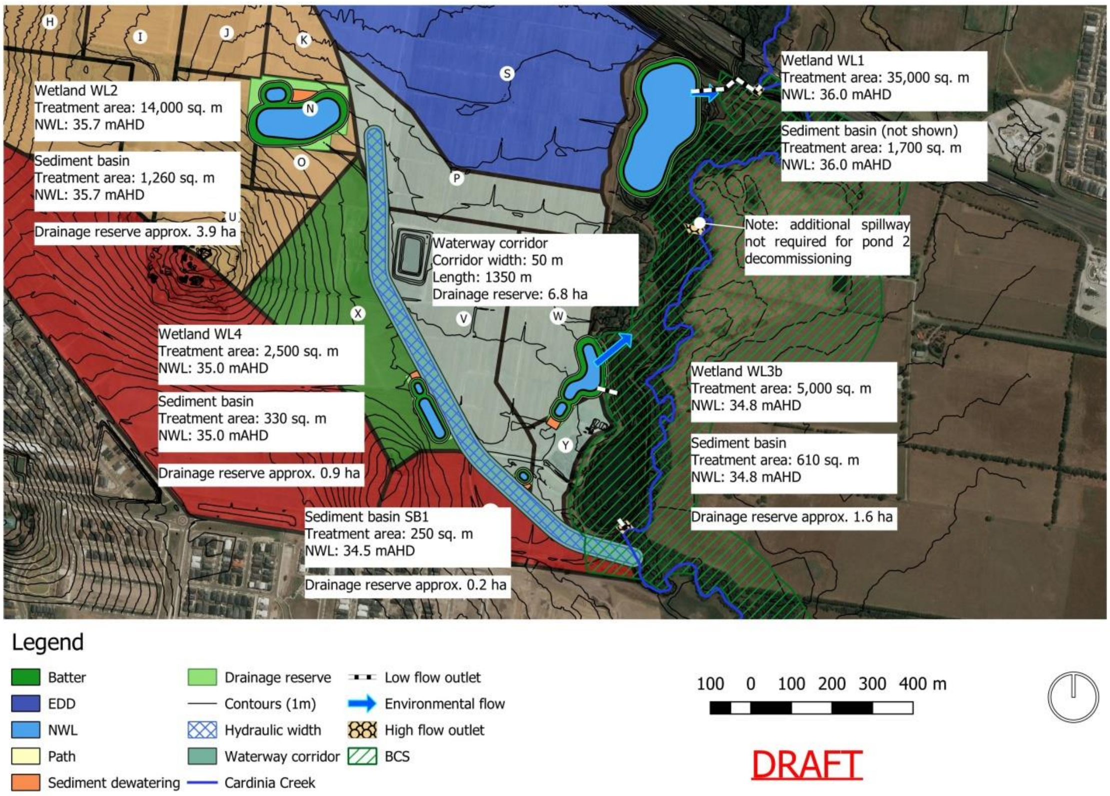



**Figure 19. Option 2b: "north -south waterway corridor" layout which retains the existing house**

***Phase 1 evaluation***

The options for phase 1 have been evaluated in terms of:

- Ability to achieve on-going environmental watering regime
- Temporary and permanent disturbance to existing habitat
- Urban form and alignment with DSS principles
- Footprint within developable land
- Cost

A summary of the evaluation is provided in Table 6.

## Table 6 : Phase 1 Evaluation of "Stormwater Treatment Options within the PSP Developable Area"

| Scenario | Ability to achieve ongoing environmental watering regime | Temporary and permanent disturbance to existing habitat | Urban form and alignment with DSS principles | Footprint within developable land (ha) | Total capital cost of assets | Total cost including land | Notes |
|---|---|---|---|---|---|---|---|
| 1 - west-east waterway corridor | Pond 0: Good; Pond 2: Good; Pond 3: Good<br>The construction of wetland WL1 within Pond 1 will regulate flow to Pond 0 and Pond 2 to meet the environmental watering needs. A control structure within the constructed waterway will divert flows between the 3mth-1 year ARI to sustain Pond 2. Pond 0 currently has a 40ML capacity that "wets and dries" based on one fill approximately every five years. Therefore the proposed option 1 includes a high level weir crest that will be set to divert a nominated recurrence interval flow (Q1 or Q5) from Pond 1 to Pond 0 to maintain or enhance the existing habitat conditions. Option 1 has a proposed upstream catchment of around 152ha, which can deliver around 45ML in a Q5 event.<br>The construction of wetland WL3 will enable treated low flows to outfall south into the open water zone of Pond 3 to sustain the permanent hydrologic regime of this zone. A higher sill or trigger level within wetland WL3 will enable infrequent flows to spill to the north and into the shallow ephemeral zone of Pond 3 to support seaonsal wetting and drying of this area. An earthern "in pond" mound will provide two different water levels to be provided within Pond 3. | Pond 0: 350 $m^2$; Pond 2: 900 $m^2$; Pond 3: 110 $m^2$<br>Low flow pipe outfall to Cardinia Creek (near freeway) from wetland WL1. Alignment to follow existing access track to minimise disturbance to vegetation/habita along Cardinia Creek. High flow spillway (10 metre crest) from Pond 0 to Cardinia Creek that will disturb some vegetation/habitat.<br>West-east constructed waterway will need to outfall to Cardinia Creek. Habitat disturbance will be around 20 metres (ie not the full upstream constructed waterway corridor). Low flow pipe outfall from lower section of Pond 3 to Cardinia Creek, which will potentially disturb 5 metres of existing habitat. | Option 1 does not follow Melbourne Water's standard scheme approach of aligning the waterway corridor to follow the "valley floor". The impacts associated with diverting the waterway corridor "west-east" includes additional cut/depth required for the waterway (and therefore wider corridor width to accommodate), some localised filling to the north of the SB2 drainage reserve and minor filling along the existing north-south valley floor. The benefits of the waterway diversion are a reduced land take (due to a much shorter length) and potentially better ability to achieve the environmental watering regime for Pond 0. However whilst Option 1 has a lower overall cost, the location of the west-east waterway corridor is on a different land title to the natural north-south waterway corridor. Normal scheme principals do not reimburse land costs associated with waterway corridors. This presents a significant operational issue for Melbourne Water regarding "equity" with respect to a different landowner receiving the benefit to the one who bears the cost. As a result it will be necessary to seek the agreement of both landholders to ensure commerical interests are not impacted. For example this could potentially take the form of an agreement between the two parties to undertake a land swap or a monetary compensation. | 10.1 | $ 9,660,000 | $ 19,760,000 | Assumes developable land at $1 million per hectare. Includes offsite disposal of excess cut in asset cost, which increases the cost significantly |
| 1 - west-east waterway corridor preserving existing Ballieu house | Good; Good; Good<br>As per option 1 | 350 $m^2$; 900 $m^2$; 110 $m^2$<br>As per option 1 | As per option 1. In addition, option 1b is not ideal as the optimum location for a wetland would include the removal of the existing house. If the house and surrounds were to remain, the required stormwater asset would need to be split either side of the house. This would require an additional wetland with associated sediment pond. These additional assets will not only cost more from a capital perspective but will also cost more to mainatin in the long term. | 11.5 | $ 10,040,000 | $ 21,540,000 | Assumes developable land at $1 million per hectare. Includes offsite disposal of excess cut in asset cost, which increases the cost significantly |
| 2 - north-south waterway corridor | Moderate; Good; Good<br>The construction of wetland WL1 within Pond 1 will regulate flow to Pond 0 and Pond 2 to meet the environmental watering needs. A control structure within the constructed waterway will divert flows between the 3mth-1 year ARI to sustain Pond 2. Pond 0 currently has a 40ML capacity that "wets and dries" based on one fill approximately every five years. Therefore the proposed option 1 includes a high level weir crest that will be set to divert a nominated recurrence interval flow (Q1 or Q5) from Pond 1 to Pond 0 to maintain or enhance the existing habitat conditions. Option 2 has a proposed upstream catchment of around 50ha, which can only deliver around 16ML in a Q5 event. Therefore due to the smaller contributing catchment Pond 0 will potentially be more suceptible to "drying out" quicker and for a longer period of time.<br>The construction of wetland WL3 will enable treated low flows to outfall south into the open water zone of Pond 3 to sustain the permanent hydrologic regime of this zone. A higher sill or trigger level within wetland WL3 will enable infrequent flows to spill to the north and into the shallow ephemeral zone of Pond 3 to support seaonsal wetting and drying of this area. An earthern "in pond" mound will provide two different water levels to be provided within Pond 3. | 350 m2; 150 m2; 380 m2<br>Low flow pipe outfall to Cardinia Creek (near freeway) from wetland WL1. Alignment to follow existing access track to minimise disturbance to vegetation/habita along Cardinia Creek. High flow spillway (10 metre crest) from Pond 0 to Cardinia Creek that will disturb some vegetation/habitat.<br>Low flow pipe outfall from Pond 2 to Cardinia Creek, which will potentially disturb 5 metres of existing habitat.<br>North-south constructed waterway will need to outfall to Cardinia Creek. Habitat disturbance will be around 20 metres (ie not the full upstream constructed waterway corridor). | Follows Melbourne Water's standard DSS principals. In particular the accepted approach that a waterway corridor should follow the natural valley floor. From an asset management perspective Option 2 has one additional treatment asset (ie a sediment pond in the western side of the waterway corridor) compared to Option 1 | 11.4 | $ 10,620,000 | $ 22,020,000 | Assumes developable land at $1 million per hectare. Includes offsite disposal of excess cut in asset cost, which increases the cost significantly |
| 2b - north-south waterway corridor preserving existing Baillieu house | Moderate; Good; Good<br>As per option 2 | 350 m2; 150 m2; 380 m2<br>As per option 2 | Follows Melbourne Water's standard DSS principals. In particular the accepted approach that a waterway corridor should follow the natural valley floor. From an asset management perspective Option 2b is not ideal as the optimum location for a wetland would include the removal of the existing house. If the house and surrounds were to remain, the required stormwater asset would need to be split either side of the house. This would require an additional sediment pond and an additional wetland. These additional assets will not only cost more from a capital perspective but will also cost more to mainatin in the long term. | 12.2 | $ 10,720,000 | $ 22,920,000 | Assumes developable land at $1 million per hectare. Includes offsite disposal of excess cut in asset cost, which increases the cost significantly |

## 7.4 Phase 2 – options for existing embankments

The existing pond embankments are a safety risk in the long term and as a result cannot remain as they are. There are three fundamental options as follows:

***Decommission***

Decommissioning the embankment involves removing the bund height to match the original natural ground. Construction works would happen on the upstream face to avoid disturbance on the creek side of the existing embankment. Refer to Figure 20. Decommissioning will generally result in the loss of water storage and significantly alter the existing upstream environs and habitat.

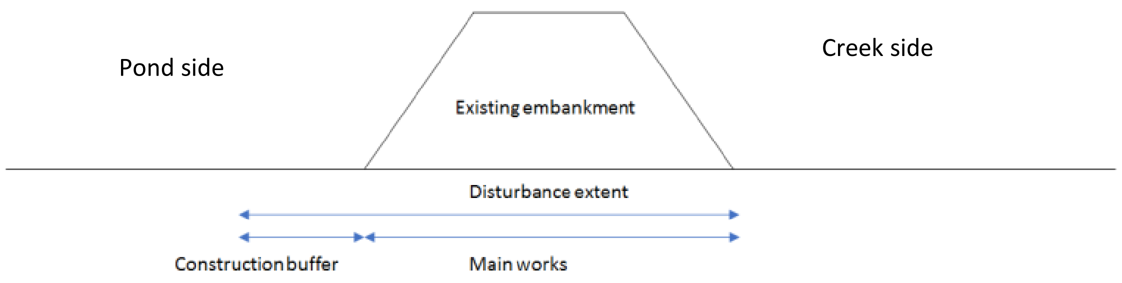



**Figure 20. Conceptual diagram for embankment decommission**

***Rebuild***

Rebuilding the embankment initially requires removal or decommissioning followed by the construction of a new core embankment with filters and maximum upstream and downstream embankment slopes of 1 in 3. Refer to Figure 21.

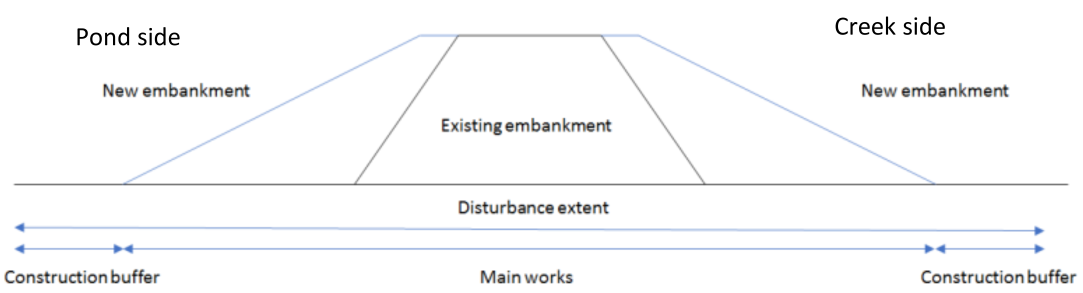



**Figure 21. Conceptual diagram for embankment rebuild**

***Remediate***

Embankment rehabilitated through upgrade to appropriate standards which will likely include filter protection constructed within the existing embankment footprint or upstream to avoid impacting Dwarf Galaxias habitat downstream of the embankment (temporary works impact likely 10-15m upstream of embankment). The maximum upstream embankment batter slope is 1 in 3. Refer to Figure 22. It is likely rehabilitation will require draining of the ponds for 2-3 months (maximum) to facilitate construction. This could be timed to avoid impact to Latham's Snipe during migratory periods. The effect on other state listed duck species would be temporary and individuals are expected to return after the ponds re-fill. Alternatively a temporary coffer dam could be installed to separate existing habitat west of the embankment from the construction footprint, maintaining a permanent water depth in undisturbed sections during construction

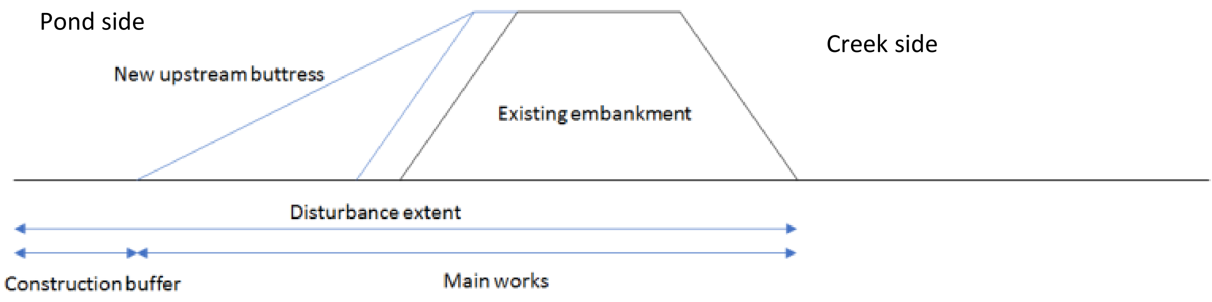



**Figure 22. Conceptual diagram for embankment remediation**

***Phase 2 evaluation***

The options for phase 2 have been evaluated in terms of:

- Ability to achieve on-going environmental watering regime
- Temporary and permanent disturbance to existing habitat
- Capital cost

A summary of the evaluation is provided in Table 7.

## 7.5 Recommendation

Based on the phase 1and phase 2 evaluation and assessment, it is my opinion that the preferred drainage strategy should be based on the following elements:

Option 1: "west-east waterway corridor"

- Remediation/rehabilitation of the Pond 0 embankment
- Decommissioning of the Pond 1 embankment in conjunction with the construction of wetland WL1
- Decommissioning of the Pond 2 embankment to allow reconnection to the Cardinia Creek floodway and enhance
- Remediation/rehabilitation of the Pond 3 embankment

In my opinion Option 1 delivers the best overall outcome in terms of the key principles of stormwater quality, stormwater quantity, ecology, adaptive/resilient assets, safety and land take/cost.

If the existing Baillieu house needs to be retained then Option 1b would deliver similar outcomes to Option 1.

## Table 7: Phase 2 - Embankment and Pond Options within the BCS

| Scenario | Ability to achieve ongoing environmental watering regime | | | Temporary and permanent disturbance within the BCS | | | Capital cost associated with embankment lengths along each pond | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pond 0 | Pond 2 | Pond 3 | Pond 0 | Pond 2 | Pond 3 | Pond 0 | Pond 1 | Pond 2 | Pond 3 | |
| | Poor | Moderate | Poor | 5870 $m^2$ | 4300 $m^2$ | 10970 $m^2$ | $ 798,000.00 | $ 320,000.00 | $ 439,000.00 | $ 1,149,000.00 | |
| **1 - Base case - embankment decommissioning** | Embankment decommissioning implies removal of the entire embankment. This is associated with a large (almost total) reduction in storage capacity of each pond. For pond 0, this removes the ability of the pond to sustain the long-term wetting and drying cycles associated with existing values. Reconnection with the Cardinia Creek floodplain increases susceptibility to invasion by predatory aquatic species. For pond 2, decommissioning will remove existing deep water but increase opportunities for creation of marshy habitat of higher value to key species (e.g. Latham's Snipe). For pond 3, decommissioning removes deep open water habitat with high value to state listed duck species and exposes islands to access by predators. | | | Embankment decommissioning requires a minimum temporary or permanent works footprint extending from 5m west of the upstream embankment toe to the downstream toe. This relates to approximately 10m upstream and 5m downstream of the centreline of the embankment crest on average. Note that decommissioning has wider habitat implications associated with a reduction in water depths and extent. For example, this could eliminate all habitat for state listed waterbirds in pond 3 (representing approximately 33000 m2 of additional impact) | | | This is cost for each embankment option along the length of embankment for each pond. | | | | This is the total temporary and permanent impact within the BCS. For a breakdown of individual species refer to embankment scenario plans |
| | Good | Moderate | Good | 11830 $m^2$ | 9000 $m^2$ | 22190 $m^2$ | $ 1,878,000.00 | $ 751,000.00 | $ 1,033,000.00 | $ 2,703,000.00 | |
| **2 - Embankment rebuild** | Rebuilt embankments can preserve the existing regime of all ponds. However in the case of pond 2, rebuilding embankments misses an opportunity to create a marshy habitat of higher value to key species (e.g. Latham's Snipe). Pond 2 currently provides low habitat values to MNES and state listed duck species. | | | The embankment rebuild option can restore embankments to their current performance levels. However, based on the need to design the rebuilt embankment to modern standards (including a reduced slope), new embankments will have a footprint approximately three times wider than current. This leads to a temporary or permanent disturbance of between 15-18m either side of the embankment crest. This presents a significant impact on existing habitat, especially for swamp scrub vegetation in the Cardinia Creek floodplain. | | | | | | | This is the total temporary and permanent impact within the BCS. For a breakdown of individual species refer to embankment scenario plans |
| | Good | Moderate | Good | 8550 $m^2$ | 5810 $m^2$ | 14770 $m^2$ | $ 1,090,000.00 | $ 436,000.00 | $ 600,000.00 | $ 1,569,000.00 | |
| **3 - Embankment rehabilitation (upstream filter buttress)** | As option 2 | | | The embankment rehabilitation option can restore embankments to their current performance levels. However, based on the need to design the rehabilitated upstream side of the embankment to modern standards new embankments will have a footprint approximately three times wider than current. Note this is only the upstream (west) side of the embankment. This leads to a temporary or permanent disturbance of between 15-18m on the upstream side and 5m on the downstream side of the embankment crest. Impacts to swamp scrub vegetation can be largely avoided. | | | | | | | This is the total temporary and permanent impact within the BCS. For a breakdown of individual species refer to embankment scenario plans |

# 8 Minta City Proposal

I have reviewed the Minta City proposal which includes a document titled “Minta City Proposal (14 March 2018)” and an overview presentation titled “Minta City Presentation (19 March 2018)”.

The Minta City vision includes a reference to “stitching together urban and natural open spaces” through an urban design principle to “integrate the blue and green network”. Whilst there is no specific reference or details on the drainage strategy that underpins the proposal at a high level it incorporates a network of wetlands and green spaces which is consistent with the philosophical approach to the exhibited Minta Farm PSP.

Figure 23 compares the concept masterplan from the Minta City proposal presentation with the exhibited PSP. What is evident is that the concept masterplan is generally consistent with the exhibited PSP from a drainage perspective in that it includes a drainage reserve for wetland WL2, the “north-south” waterway corridor and a drainage reserve for wetland WL1. The Minta City concept masterplan also includes a “west-east” green space corridor which is significantly wider than the exhibited Minta Farm PSP. The Minta City proposal extends the north-south waterway corridor to the WL2 drainage reserve, which in my opinion is a good outcome.

If the preferred drainage strategy as outlined in Section 7.5 is adopted, it is my opinion that the Minta City concept masterplan could be relatively easily adapted without significant change to proposed urban structure and layout. The drainage reserve WL2 could be reduced, whilst the “west-east” green space corridor could be transformed into a “west-east” waterway corridor. Whilst the concept masterplan does not have a scale or dimensions, it appears that the “west-east” green space corridor is in the order of 50-60 metres. This width is not significantly different to the “west-east” waterway corridor width of 60 metres on the preferred drainage strategy option.



**Figure 23. Minta City concept masterplan on the left; exhibited PSP on the right**

# 9 Overland flow paths

The Minta Farm PSP and drainage strategy that underpins it needs to ensure that overland flow paths can safely convey the 1% AEP rainfall event via road reserves or waterway corridors. The town centre is located within the valley floor or low point in the topography. As a result overland flows from the upstream catchment, which are proposed to be conveyed via road reserves, will naturally want to converge towards the valley floor based on traditional road gradings. The pinch point for the safe capacity of overland flows along a single road reserve is located within the vicinity of the town centre. As a result it is important that the PSP informs the urban structure to ensure adequate overland flow capacity is provided, without relying upon the sub-optimal outcome of upsizing underground pipes to carry more of the flow. In my opinion this could potentially be achieved by the following options:

- Provide a wider “east-west” road (ie wider than the standard 16 metres to accommodate flood events through the road system) upstream of SB2 within the town centre. A sunken “green” median strip could enhance the flow conveyance capacity
- Ensure that the future urban design layout incorporates multiple road reserves to safely convey overland flows to the SB2 drainage reserve. For example the VPA’s concept layout for the town centre as shown in Figure 24.

**Figure 24. Concept rod network layout within the town centre and surrounds**

# 10 Summary

In summary, my findings with respect to the proposed drainage strategy and the exhibited PSP are provided below.

In my opinion the exhibited PSP and drainage strategy needs to be amended so that it integrates and responds to the existing site constraints and values. By its nature, implementation of the PSP and the corresponding land use change will dramatically alter the hydrologic regime that currently supports the existing habitat and ecological values. As a result it is imperative that the drainage strategy considers and integrates the needs of the following key pillars:

- stormwater quality,
- stormwater quantity,
- ecology
- safety.

Alluvium has been working collaboratively with Melbourne Water, DELWP and the VPA to develop drainage strategy scenarios that respond to the above needs. A summary of the approach and options is provided in Section 7.

As a result I recommend that the PSP be amended to reflect the alternative configuration as presented in this evidence.

Based on the phase 1and phase 2 evaluation and assessment, it is my opinion that the preferred drainage strategy should be based on the following elements:

Option 1: “west-east waterway corridor”

- Remediation/rehabilitation of the Pond 0 embankment
- Decommissioning of the Pond 1 embankment in conjunction with the construction of wetland WL1
- Decommissioning of the Pond 2 embankment to allow reconnection to the Cardinia Creek floodway and enhance
- Remediation/rehabilitation of the Pond 3 embankment

In my opinion Option 1 delivers the best overall outcome in terms of the key principles of stormwater quality, stormwater quantity, ecology, adaptive/resilient assets, safety and land take/cost.

If the existing Baillieu house needs to be retained then Option 1b would deliver similar outcomes to Option 1.

If the preferred drainage strategy as outlined in Section 7.5 is adopted, it is my opinion that the Minta City concept masterplan could be relatively easily adapted without significant change to proposed urban structure and layout. The drainage reserve WL2 could be reduced, whilst the "west-east" green space corridor could be transformed into a "west-east" waterway corridor. Whilst the concept masterplan does not have a scale or dimensions, it appears that the "west-east" green space corridor is in the order of 50-60 metres. This width is not significantly different to the "west-east" waterway corridor width of 60 metres on the preferred drainage strategy option.

The pinch point for the safe capacity of overland flows along a single road reserve is located within the vicinity of the town centre. As a result it is important that the PSP informs the urban structure to ensure adequate overland flow capacity is provided, without relying upon the sub-optimal outcome of upsizing underground pipes to carry more of the flow. In my opinion this could potentially be achieved by the following options:

- Provide a wider "east-west" road (ie wider than the standard 16 metres to accommodate flood events through the road system) upstream of SB2 within the town centre. A sunken "green" median strip could enhance the flow conveyance capacity
- Ensure that the future urban design layout incorporates multiple road reserves to safely convey overland flows to the SB2 drainage reserve. For example the VPA's concept layout for the town centre as shown in Figure 24.

I have made all the enquiries 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.

# Attachments

- “Input into the Minta Farm Drainage Strategy” prepared by Biosis (November 2017)
- “Preliminary review of the Minta Farm water dams” prepared by Newman Engineering (December 2017)
- “Geotechnical investigation, Minta Farm wetlands” prepared by AS James (October 2017)

10 November 2017

Mr Jonathon Mclean
Alluvium Consulting
Level 1, 105-115 Dover St,
Cremorne Vic 3121

Dear Jonathon,

## Re: Input into the Minta Farm Drainage Strategy

**Project no. 25215**

This report provides background information and guiding principles to inform the Minta Farm Development Services Strategy.

This information is intended to assist Alluvium in developing drainage assets within Minta Farm PSP in a manner which maintains and where possible enhances biodiversity values, particularly populations of Dwarf Galaxias (EPBC-listed migratory shorebirds, Growling Grass Frog and various species of threatened and notable waterbirds.

The information addresses Task 1.4 Ecological Function. A separate report will address Task 2.3 Ecological Response. The aim of this report is to;

- Provide background information on the biodiversity habitat values from existing information sources
- Undertake a site inspection to confirm values and identify ecological constraints and opportunities
- Identify areas that provide high quality habitat values or that could conceivably be modified to provide drainage assets that serve as potentially valuable wetland habitats for key species.
- Identify areas of low habitat value that may be suitable for remodelling to a stormwater treatment asset.

The information provided here is based on a review of available literature pertinent to the site, as outlined in the References and a site inspection conducted by Alluvium and Melbourne Water.

## Ecological values

### Native vegetation

The ecological values of the site are described in Practical Ecology (2011). Most of the PSP supports non-native vegetation of low ecological value. Native vegetation is mostly confined to the riparian area along Cardinia Creek. The predominant ecological vegetation class (EVC) is Swamp Scrub, which is dominated by Swamp Paperbark *Melaleuca ericafolia* and extensive areas of wetland EVCs and all these plant communities are listed as threatened in the Gippsland Plain bioregion. There are two wetlands (online dams west of Gum Scrub Creek that support native vegetation and provide waterbird habitat but these are not considered to have the conservation significance of the created wetlands adjacent to Cardinia Creek.

**Waterbirds**

The constructed wetland complex on Cardinia Creek is very high quality habitat for waterbirds and a number of threatened waterbirds have been recorded here including ducks (Blue-billed Duck, Australasian Shoveler, Musk Duck and Freckled Duck), and wading birds such as the Intermediate Egret, Great Egret and Royal Spoonbill. The large southern wetland (Pond 3) also supports breeding colonies of waterbirds including Little Pied Cormorant, Little Black Cormorant and Pied Cormorant as well as ibises and spoonbills. The wetlands also provide extensive habitat for frogs. Pond 3 is the most significant wetland for waterbirds within the PSP.

**Dwarf Galaxias**

Surveys conducted in Cardinia Creek on the eastern boundary of the site confirmed the presence of this threatened fish species (Biosis Research 2012). The record along an anabranch of Cardinia Creek at Minta Farm is a new site located 900m downstream of most of the existing records of the species and the habitat at this location is considered high quality breeding and drought refuge sites (Biosis Research 2012). Cardinia Creek is known to be nationally important habitat for Dwarf Galaxias and this been one of the reasons for the designation of the conservation area along Cardinia Creek in the Biodiversity Conservation Strategy (BCS (DEPI 2013b). Dwarf Galaxias have not been recorded in any of the existing constructed wetlands in Minta Farm (west of Cardinia Creek). The wetlands are likely to be infested with exotic predatory fish of various species and in their current form, may not provide high quality habitat for Dwarf Galaxias.

**Growling Grass Frog**

Under the BCS, Conservation Area 36 (Cardinia Creek) has been established to provide habitat for the nationally threatened Growling Grass Frog (DELWP 2017). Areas of Strategic Importance (ASI) for Growling Grass Frog have been identified through population modelling and expert elicitation. The areas of Strategic Importance have been identified so that critically important current and future (created) habitat for the species is protected from incompatible urban development. The existing wetland complex on the west side of Cardinia Creek in Minta Farm and Cardinia Creek itself are not identified as ASI within Conservation Area 36 but this area incorporates areas of "other terrestrial habitat" and "terrestrial habitat buffers to ASI and waterway" (Page 49 of the Growling Grass Frog Masterplan). Areas marked on the Masterplan mapping as "other terrestrial habitat" are generally the most suitable areas for urban infrastructure (Figure 1). However, ASI are identified within the PSP on the west side of Cardinia Creek.

**Migratory species**

Under the Biodiversity Conservation Strategy for Melbourne's Growth Corridors (DEPI 2013), there is a requirement for the protection of wetlands (and buffers around wetlands) known or likely to contain nationally important populations of migratory species. The Program Report for the Melbourne Strategic Assessment (REF) commits to conservation outcomes for migratory species as follows:

- A network of small and large conservation areas including a diversity of wetland areas managed for their migratory species and other wetland values, particularly in areas distant from urban development
- Improved management and design of retained and constructed wetlands to maximise habitat opportunities for migratory species
- Major new area of re-established wetlands managed for water quality mitigation and biodiversity conservation
- Improved water quality entering Port Phillip Bay Ramsar site
- Limited indirect disturbances (e.g. dogs) to identified wetlands.

The Minta Farm wetlands in the Minta Farm Precinct are considered likely to support nationally important populations of some migratory waterbirds (DEPI 2013). The importance of these wetlands for migratory bird species is based on a biodiversity report prepared for the Growth Areas Authority by Practical Ecology for C21 Business Park (Practical Ecology 2011). This report lists a number of migratory bird species that are either known or predicted to occur within the Minta Farm wetlands (Table 1). However, apart from Latham's Snipe, the majority of these species are in fact not listed as migratory species under the EPBC Act.

No other listed migratory waterbirds are known or considered likely to occur within the Minta Farm wetlands.

Unfortunately the errors in the Practical Ecology report have flowed on to the Melbourne Strategic Assessment team at the Department of Environment, Land, Water and Planning (DELWP) and this has driven migratory bird impact assessment requirements within the PSP for waterbird species that are in fact not migratory. Many of these species are nonetheless listed as threatened in Victoria under either the *Flora and Fauna Guarantee Act 1988* (FFG Act) and/or the DELWP Advisory List of threatened vertebrate fauna (DSE 2013). Biosis have advised the MSA team at DELWP these errors in relation to the mistaken significance of the PSP to migratory shorebirds (Hugh Stanford, pers. comm.) It was subsequently agreed that the only migratory shorebird species likely to use the site is Latham's Snipe (albeit not necessarily supporting an ecologically significant population) and that any Drainage Strategy should have regard to maintaining or improving habitat for Latham's Snipe. The MSA team also advised that the Strategy should have regard to the maintenance of recognised high quality waterbird foraging and breeding habitat, particularly the values identified in Pond 3.

**Significance of Minta Farm to Latham's Snipe**

To understand the significance of Minta Farm to migratory shorebirds, including Latham's Snipe, Biosis completed targeted surveys for them within the wetland complex and in the farm dams within the cropping areas (Wetlands A and B or Practical Ecology 2011). The surveys were carried out in accordance with the *EPBC Act Policy Statement 3.21- Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia 2017). Biosis undertook five targeted surveys for Latham's Snipe during both the migratory season (21 December 2011, 19 & 31 January 2012 and 14 February 2012) and non-migratory season (20 June 2012). No Latham's Snipe were recorded during survey. No other migratory shorebirds were recorded. Under Policy Statement, important Latham's Snipe is described as areas that have been previously identified as internationally important for the species, or areas that support at least 18 individuals of the species. Based on these results, is unlikely to meet the the minimum criteria for classification as Important Habitat for Latham's Snipe or any other migratory shorebird.

However, given that the species (number unknown) was recorded by Practical Ecology (2011), and given there are areas of suitable wetland habitat available, it is likely that small numbers use the site on occasion.

**Table 1 Waterbird species listed as migratory by Practical Ecology (2011) known or considered likely to occur at Minta Farm**

| Species | Listed as migratory under the EPBC Act?* | Victorian Status | Likelihood of occurrence |
|---|---|---|---|
| ***Anas rhynchotis*** **Australasian Shoveler** | No | vu | Recorded at Minta Farm and the large, well-vegetated wetlands provide high quality habitat for the species. |
| ***Oxyura australis*** **Blue-billed Duck** | No | en,L | Recorded at Minta Farm and the large, well-vegetated wetlands provide high quality habitat for the species. |

| Species | Listed as migratory under the EPBC Act?* | Victorian Status | Likelihood of occurrence |
|---|---|---|---|
| ***Ardea modesta*** **Eastern Great Egret** | No | vu,L | Recorded at Minta Farm and all the wetlands provide high quality habitat for the species. |
| ***Aythya australis*** **Hardhead** | No | vu | Recorded at Minta Farm and the large, well-vegetated wetlands provide high quality habitat for the species. |
| ***Platalea regia*** **Royal Spoonbill** | No | nt | Recorded breeding at Minta Farm (Practical Ecology 2011). |
| **Gallinago hardwickii** **Latham's Snipe** | Yes | nt | Recorded on site by Practical Ecology. The site only supports foraging habitat for this species which breeds in Japan and spends time in Australia during the austral summer. Highest quality habitat for this species at Minta Farm are shallow, well-vegetated wetlands (or parts thereof) with significant fluctuations in water level, particularly Pond 0. Deeper, steep-sided more permanent waterbodies are not preferred habitat. |

## Areas that currently provide high habitat value

Areas that currently provide high habitat value within the Minta Farm PSP (in order of importance)

- Cardinia Creek main channel and anabranch (Dwarf Galaxias habitat and significant native vegetation)
- Pond 3 (high quality, large, deep-water waterbird habitat, including several threatened ducks and rookeries of several waterbird species and shallow, muddy area at its northern end that provides habitat for crakes, rails and potentially Latham's Snipe.
- Pond 0 (ephemeral / fluctuating wetland providing habitat for Latham's Snipe and wading waterbirds and habitat for numerous frogs. Provides seasonally dry conditions that allow for a wetland free of predatory/exotic fishes.
- Pond 2 (foraging habitat for waterbirds and habitat for frog species)
- Pond 1 (foraging habitat for waterbirds and habitat for frog species)
- Wetlands A and B and Drainage Lines identified in Practical Ecology (2011).

## Lower quality habitat areas

Areas that could conceivably be developed as stormwater treatment assets without compromising important biodiversity values on the site include the following:

- Drainage lines
- Areas identified as "Other Terrestrial Habitat" in Conservation Area 36 (DELWP 2017a, P42)
- Areas of non-native vegetation/degraded Treeless Vegetation
- Pond 1 (this has high value as waterbird habitat but could be modified to a stormwater treatment asset without significantly altering its value as waterbird habitat)

## Recommendations

The aim of the drainage strategy at Minta Farm should be to maintain and where possible enhance native vegetation and habitat values for the key species or groups of species identified within the PSP. When developing the Drainage Strategy for Minta Farm, the key ecological attributes that should be maintained within the site include:

- Large, deep (>1.5m) waterbodies which is preferred habitat for threatened ducks (Hardhead, Musk Duck, Freckled Duck, Australasian Shoveler) and other species including fish-feeding birds (e.g. cormorants).
- The islands in Pond 3.
- To the fullest extent practicable, minimise disturbance to any native vegetation in the vicinity of Cardinia Creek especially within BCS Conservation Area 36.
- Shallow and or ephemeral wetlands (e.g. Pond 0 and shallow northern end of Pond 3, which provide habitat for Latham's Snipe and egrets and also provide excellent frog breeding habitat.
- Cardinia Creek, especially anabranches which provide important habitat for Dwarf Galaxias.

The key ecological attributes that should be enhanced within the site include:

- Develop water quality treatment assets in areas identified as low quality habitat.
- Development of one or more wetlands designed specifically for Growling Grass Frog adopting the habitat design standards. In particular, investigate the opportunity to create wetlands that are not hydrologically connected to Cardinia Creek (potentially Pond 2).
- Areas of native vegetation to provide greater protection to the riparian values along Cardinia Creek.
- Smaller wetlands with connectivity to Cardinia Creek that should be planted with shade-casting shrubs such as Swamp Paperbark, to act as potential refuge habitat for Dwarf Galaxias.
- Wetlands (including stormwater treatment assets) or parts of wetlands with extensive areas of well-vegetation shallow water (<0.5m deep) and areas of exposed mud to provide Latham's Snipe habitat.
- Ephemeral wetlands that provide high quality habitat for many frog species and may be utilised at times by Dwarf Galaxias as well as providing muddy substrates as they draw down.

In summary, the guiding principles should aim to:

- Maintain hyrological regime in Pond 0.
- Retain the current hydrological regime in Pond 3 (areas of permanent open water for foraging and breeding habitat for threatened duck species).
- Retain the breeding waterbird islands within Pond 3.
- Retain and enhance Dwarf Galaxias habitat.
- Develop at least some wetlands to include key Growling Grass Frog wetland habitat design principles as described in
- Maintain and enhance shallow areas within existing wetlands and create new shallow, well-vegetated wetlands.

# References


Biosis Research (2012) Melbourne's Strategic Assessment: Dwarf Galaxias Surveys for the South East Growth Corridor. Report to the Department of Sustainability and Environment.

Commonwealth of Australia (2017) EPBC Act Policy Statement 3.21- Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species, Department of the Environment and Energy, Canberra.

DSE (2013) Advisory List of Threatened Vertebrate Fauna in Victoria. Victorian Government, East Melbourne

DELWP (2017a) Growling Grass Frog Masterplan for Melbourne's Growth Corridors – Melbourne Strategic Assessment. Victorian Government, East Melbourne.

DELWP (2017b) Growling Grass Frog Habitat Design Standards – Melbourne Strategic Assessment. Victorian Government, East Melbourne.

DEPI (2013) Biodiversity Conservation Strategy for Melbourne's Growth Corridors. Victorian Government, East Melbourne.

Practical Ecology (2011c) Biodiversity Assessment Report C21 Business Park, PSP Area 11, Prepared for Growth Areas Authority, Melbourne

Victorian Government (2009) Delivering Melbourne's Newest Sustainable Communities – Program Report. Department of Planning and Community Development, East Melbourne

# Appendices

# Appendix 1 Figure 1 – ASI Mapping For GGF, Minta Farm

**Newman Engineering Pty Ltd**

**ABN 80606877758**

2/1 Cypress Avenue
Glen Waverley, Victoria
Australia 3150

6 December 2017

Alluvium Consulting
Level 1, 105-115 Dover St
Cremorne, VIC 3121

Attention: Jonathon Mclean

**Preliminary Review of Minta Farm Water Dam**

# 1 Introduction

Newman Engineering was commissioned by Alluvium Consulting (Alluvium) to undertake a preliminary review of the Minta Farm Dams. The scope comprised:

- Review of existing information.
- Site Inspection.
- Assessment of the structural integrity of the embankments.
- Identification of options and the way forward to address these issues.

This review is consistent with the ANCOLD Guidelines.

# 2.0 Data Review

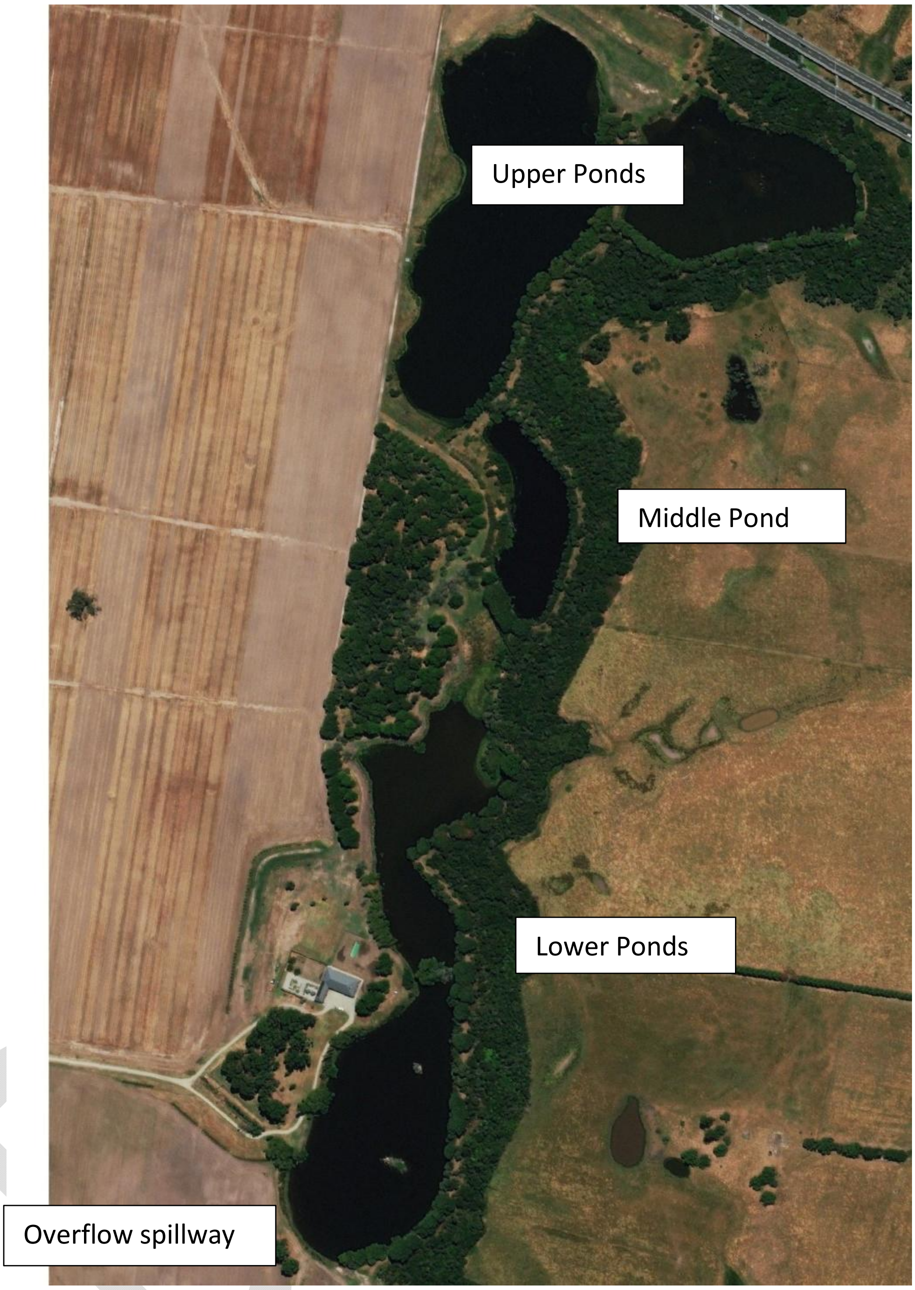
The Minta Farm dams are thought to have been constructed about 60 years ago. There is no existing information on the design, construction or operation of the dams. It is likely they were formed by cut to fill from the reservoir with nominal compaction and little if any quality control. The embankments are also unlikely to have any cutoffs in the foundation.

# 3.0 Site Inspection

On Thursday 16 August 2017 Stephen Newman of Newman Engineering Pty Ltd completed a walk over inspection of the embankments.

There are three embankments retaining water which are termed upper pond, middle pond and lower pond. These are shown on Figure 1 below.

*Figure 1: Minta Farm Dams.*




It is understood the upper dam will be removed and a wetland established with virtually no containing embankment. Therefore this pond is not assessed any further. The middle pond may or may not be retained although if retained it will have a lower full supply level reducing any consequences of failure. The lower pond is to be retained and requires a reasonable depth of water to support ecological requirements.

The lower pond embankments were up to 4m high and were impacted by undercutting from Cardinia Creek on the downstream batter resulting in local over steepening of the embankment. Survey indicates borrow for embankment construction was immediately adjacent to the embankment within the pond. This has resulted in embankments up to 5m high upstream.

The middle pond is essentially formed by an eastern embankment up to 3m high and a south western embankment across the main valley up to 5 m high.

In general, the embankments were in poor condition with large established trees on the upstream and downstream batters and areas of over steep downstream batters (1:1 in areas). No direct evidence of seepage could be seen however in winter with high creek flows and an overgrown downstream toe identifying any seepage would be difficult. General photographs of the embankments are shown in Figure 2. Total embankment lengths on site are about one kilometre.

It is understood the vegetation immediately downstream of the embankments is mostly of high conservation value. The lake bodies also form an important habitat for migratory birds.

There are pipe overflow structures although their capacity is unknown. There is also an uncontrolled informal grassed overflow spillway on natural ground at the lower pond at the southeast corner. Its capacity is unknown.

*Figure 2: Typical embankment photographs*

# 4.0 Site Investigation

## 4.1 Regional Geology

The site is underlain by quaternary alluvial deposits typically consisting of silty sandy clays and sands. At depth these quaternary deposits are underlain by Silurian sandstone/siltstone which are known to extend to considerable depths below the subject site.

## 4.2 Site Investigations

A limited site investigation program comprising 4 augered boreholes with a DCP tests adjacent to each borehole was undertaken. Hand shear vanes and laboratory moisture content, Particle Size Distribution, Atterberg Limits and Emerson Dispersion Tests were undertaken. The results are contained in the AS James report: Geotechnical investigation, Minta farm wetlands Berwick. Report No: 11 8458. Date: 23 October 2017. Key results are summarised following.

Two boreholes were placed in the lower pond embankment and one each in the middle and upper ponds.

The boreholes in the lower pond embankment encountered between 2.5-3.7 m of embankment fill comprising alluvial sandy silty clay underlain by a grey sandy clay of firm consistency with organics. The firm natural clay persisted until borehole 1 termination. In borehole 2 a very soft, sandy lens was intersected from 5.5-6.5m. Underlying this lens the grey firm sandy clay continued until termination depth of 7.5m.

In borehole 3 (middle pond embankment) the sandy silty clay fill reached a depth of 3.3m and was underlain by the grey, firm natural sandy clay. Similar to borehole 2, a soft very sandy lens was encountered from 4.5-5.0m at which the borehole was terminated.

The laboratory testing indicated clays of medium plasticity and some potential for dispersion.

# 5.0 Embankment Status

The embankments are in general in poor condition with the following observed issues:

- Large trees on the embankment;
- Areas of downstream scour and oversteepening;
- Nominal compaction of the embankment;
- Likely no cutoffs;
- No filters;
- Weak foundations containing organics; and
- The possibility of potentially liquefiable sandy layers in the foundation.

It is likely in a formalised risk assessment process there would be elevated risks associated with a number failure modes including stability and piping. The reality with an old embankment such as at Minta farm is that the embankments could not be relied on as part of a new development. The design and construction of the embankment some 60 years ago is not consistent with current standards and Melbourne Waters requirements.

In addition, given the ongoing development of the downstream catchment there will likely be increasing population at risk as time progresses. This results in at least a Significant or High ANCOLD consequence category which will direct the designers to the fallback design floods as described in ANCOLD guidelines. Design elements including filters would be required within the embankment. Filter protection at any outlets would also be required.

It is difficult to envisage any embankment being considered acceptable without retrofitting filters. Spillways sized based on a risk assessment and consequence process will also be required that consider amongst other failure modes a cascade failure if the middle ponds retain water.

# 4.0 Upgrade Options

It is understood that the lower pond needs to be maintained at least close to its current configuration. This is to ensure a reasonable water depth for ecological values. The middle pond may be retained as a dam but possibly with a reduced full supply level.

Given the likely Significant or High ANCOLD consequence category the 4-5 metre high embankments retaining water will require filters and as such the existing embankment will require either reconstruction or a filter buttress added. In addition, other failure modes require addressing such as flood management and stability of the embankment. The potential for scour of any embankment due to proximity of Cardinia Creek will also need to be considered and any potential foundation liquefiable layers.

A dedicated site investigation program and detailed design process is required however if it is accepted the current embankment is unacceptable there are a number of potential upgrade options considered potentially feasible including:

- Remove and rebuild the existing embankment;

- Add a downstream filter buttress;
- Add upstream filters with connection to downstream;
- A cutoff excavated through the existing embankment such as sheet pile or cement bentonite; and
- Partial or full decommissioning.

The filter options would include foundation cutoffs and a spillway upgrade.  All optons would include reprofiling of the embankment for stability and scour protection when near Cardinia Creek.

It is understood partial or full decommissioning is only applicable to the middle pond.  A partial decommission involves reducing full supply level to a point where the consequence of failure are low enough to reduce the consequence category.

The rebuild and upstream options require the pond to be at least partially drained for up to 2-3 months to facilitate construction.  If this was not feasible the downstream option may be the only feasible option of the 3 filter options.  Rebuilding requires draining the pond and removing the existing embankment and rebuilding on the same site with cutoffs outlets and filters.  The upstream filter buttress would use the existing embankment as a buttress but the existing would not be relied on other than as a support.  There would need to be careful thought into filter outlets through the existing embankment.  A more robust solution is a rebuild of the embankment.

A cutoff may have issues with constructability in the existing embankment and would require some reprofiling of the embankment in any case.  The ponds would not likely require draining.  Dependent on the outcome of a failure modes and risk assessment filter protection may also be required. Cement-bentonite or sheetpiles could be used however durability would be an issue for the sheetpiles. Hence this option presents possibly greater cost and greater residual risk than others.

The upgrade options are compared qualitatively in the table below.  Each option is ranked 5 if best and 1 if worst for that category.   Hence the highest score is the best ranked. The rankings are subjective for comparison between these options only and are based on very limited information. This is a very high level evaluation and should not be relied on for selection of the preferred option to take to detailed design.

The table shows there is no differentiation between an embankment rebuild (similar footprint to currently) and an upstream filter for this course assessment.  Further, more detailed evaluation would likely differentiate these options however at this stage some form of filter buttress or embankment rebuild is the preferred upgrade option.

The downstream filter buttress scored the worst primarily due to the environmental impact of clearing high conservation value vegetation downstream.  The cutoff due to likely cost and residual risk.

| **Option** | **Construction cost** | **Ongoing cost** | **Residual risk** | **Environmental impact** | **Social impact** | **Score** |
|---|---|---|---|---|---|---|
| Embankment rebuild | 3 | 3 | 5 | 2 | 5 | **18** |
| Downstream filter buttress | 2 | 3 | 4 | 1 | 5 | **15** |
| Upstream filter | 4 | 3 | 3 | 3 | 5 | **18** |
| Cutoff (cement-bentonite) | 2 | 3 | 1 | 4 | 5 | **15** |

## 5.0 Closure

If you have any queries, please don't hesitate to contact the undersigned.

Yours sincerely,

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+61 (0) 417 540 650

Stephen Newman

**ALLUVIUM**

**GEOTECHNICAL INVESTIGATION**

**MINTA FARM WETLANDS**

**BERWICK**

**Report No:** 118458

Date: 23 October 2017

**GEOTECHNICAL INVESTIGATION**

By

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# 1. INTRODUCTION

1.01 **Investigation Requested By:** Geotechnical investigation was commissioned by Mr Michael Bain of Alluvium via a signed Authorization of Engagement dated 30 June, 2017.

1.02 **Purpose of Investigation:** It is proposed to undergo remedial measures on the existing embankments next to Cardinia Creek in the Minta Farm Wetlands in Berwick**.** Geotechnical Investigations were required to provide information about the subsoil profile, as well as provide information on the soil properties, identify potentially dispersive materials and perform a preliminary ANCOLD assessment.

The following information was provided by Alluvium.

- The embankment has been constructed informally using locally sourced materials approximately 60 years ago and is not expected to be compliant with current standards.
- There is a large amount of vegetation on the embankments including a number of large trees which could potentially provide a flow path for piping failure.

Our investigation comprises carrying out boreholes, sampling and conducting laboratory tests, preparation of report, and to provide information about the subsoil profile so that the feasibility of the proposed remediation works/ decommissioning can be assessed, as per the ANCOLD guidelines.

1.03 **Geology & Background:** The 1:63,360 Geological Survey of Victoria, Cranbourne sheet, indicates the site to be underlain by quaternary alluvial deposits typically consisting of silty sandy clays and sands. At depth these quaternary deposits are underlain by sandstone/siltstone deposits of the Silurian age which are known to extend to considerable depths below the subject site. The embankments under investigation however, have been constructed approximately 60 years ago and are likely to consist of locally sourced materials. The embankment is assumed to not be constructed in accordance with Australian Standard Compaction methods.

1.04 **Field Investigations:** The following field work and methods were carried out by A.S. James Pty Ltd to date.

i) **Auger Drilling:** The boreholes were drilled using a Dingo K9-4 rotary drilling rig equipped with continuous flight 110-millimetre diameter augers fitted with a tungsten carbide drill bit.

ii) **In-situ Vane Shear Strength Testing:** In-situ vane shear strength testing was carried out within the cohesive soils at shallow depths using a Pilcon hand vane tester. All in-situ vane shear strength tests were conducted in accordance with the test procedure outlined in Australian Standard 1289, “Methods of Testing Soils For Engineering Purposes,” Test Method 6.2.1.

iii) **Dynamic Cone Penetrometer Testing:** Dynamic cone penetrometer testing was conducted at borehole locations in accordance with the test procedure outlined in Australian Standard 1289, "Methods of Testing Soils For Engineering Purposes," Test Method 6.3.2, 1997.

iv) **Logging of Soil Profiles:** The soil profile encountered in the borehole was logged in accordance with Australian Standard AS 1726 - 2017, “Geotechnical Site Investigations.”

**1.05** **Laboratory Test Methods:** All soil samples were transferred to A.S. James’ National Association of Testing Authorities (NATA) registered Clayton South laboratory, where mechanical testing was undertaken by a team of trained laboratory technicians. All laboratory testing was performed in strict accordance with the test methods outlined in Australian Standard AS 1289, “Method of Testing Soils for Engineering Purposes,” as follows:

| | **AS Test Method** |
|---|---|
| • Moisture Content | 1289 2.1.1 |
| • Particle Size Distribution | 1289 3.6.1, 3.6.3 |
| • Atterberg Limits | 1289 3.1.2, 3.2.1, 3.3.1, 3.4.1 |
| • Emerson Dispersion Test | 1289 3.8.1 |

## 2. RESULTS

### 2.1 FIELD TESTING

**2.1.1** **Site Description:** At the time of the investigation the following site features were noted:

- The subject site is currently occupied by three (3) ponds adjacent to Cardinia Creek, with embankments separating each pond from the creek and the other ponds.
- No major failures zones were observed during the site inspection.
- The embankments are approximately 1km in length and up to 4m high at their peak.
- There are numerous large trees along the entire length of the embankment.
- No boulders or rock are visible on the ground surface and none would be expected.

**2.1.2** **Bore Locations:** A total of four (4) boreholes, comprising two (2) boreholes in the embankment of the southern pond, one (1) borehole in the embankment of the central pond and one (1) borehole in the embankment of the northern pond, have been carried out at the subject site. The borelogs are given on Figures 2-5.

**2.1.3** **Dynamic Cone Penetrometer:** Dynamic Cone Penetrometer testing was carried out adjacent to selected boreholes. Results are given on Figures 6 – 9.

**2.1.4** **Sub-Surface Soil Profile:** Generally the soil profile encountered in boreholes 1 and 2 (southern pond embankment) consists of between 2.5-3.7 m thick fill comprising of sandy silty clay underlain by a grey sandy clay of firm consistency. In both boreholes 1 and 2 organics were encountered in the natural clay above the same depth of 4.0m. In borehole 1 the firm natural clay persisted until the termination depth of 5.0m. In borehole 2 the ground was probed further down and encountered a very soft, very sandy lense from 5.5-6.5m. Underlying this lense the grey firm sandy clay continued until the termination depth of 7.5m.

In borehole 3 (central pond embankment) the sandy silty clay fill encountered reached a depth of 3.3m and was underlain by the grey, firm natural sandy clay. Similar to borehole 2, a soft very sandy lense was encountered from 4.5-5.0m at which the borehole was terminated.

In borehole 4 (northern pond embankment) the sandy silty clay fill encountered reached a depth of 2.7m. This fill was underlain by a natural firm grey mottled brown sandy clay which persisted until the termination depth of 3.5m.

**2.1.5** **Ground Water:** Ground water was encountered within boreholes 1, 2 and 3 at a depth of 4.5 metres. Groundwater was not encountered in borehole 4. It should also be noted that following prolonged periods of rainfall the surface fill and shallow clays may be susceptible to moisture ingress, thereby significantly reducing the workability and strength of both the surface soils and the underlying clays at shallow depths.

## 2.2 LABORATORY TESTING

**2.2.1** Upon receipt in the laboratory the disturbed soil samples retrieved from each of the boreholes have been used for carrying out Moisture Content, Particle Size Distribution, Atterberg Limits and Emerson Dispersion Tests.

**2.2.2** **Laboratory Testing:** Detailed test results sheets are given in Appendix 1.

From the results of the laboratory tests, attention is drawn to the following aspects of the results:

i) Particle Size Distribution Test: Particle Size Distribution (Sieve) analysis tests were carried out on collected samples. The clay content (% by weight passing 0.005mm as per USBR (a) definition) of the natural soil was found to be 49%.

ii) Atterberg Limit: The two (2) Atterberg limit tests were performed on samples from both within the fill embankment and within the natural soil below the embankment. Results of the Atterberg Limit test indicate the clays are both of medium plasticity (Liquid limits of 44-46% and Plasticity Indexes 16-17%) and they exhibit some potential to change in volume when subjected to changes in moisture content.

iii) Emerson Dispersion Testing: Emerson dispersion classification testing conducted on two (2) clay samples at different depths within the embankment indicated the samples are prone to slaking when wet and showed some evidence of dispersion (Emerson classification number - 2).

# 3. AUSTRALIAN NATIONAL COMMITTEE ON LARGE DAMS (ANCOLD) ASSESSMENT

**3.01** **General:** In order to ensure the stability and seismic effects do not contribute to the proposed retarding basin failure, seismic and stability checks were analysed based on ANCOLD guidelines (Australian National Committee on Large dams). (R*eference Guidelines for Design of Dams for Earthquake – August 1998)*. It is recognised these guidelines are not specifically for embankments of this type but are a useful checklist.

**3.02** **Proposed Guidelines:** The guidelines proposed for seismic stability assessment of embankment dams illustrated in ANCOLD Flow chart was used for the analysis (refer Figure 10 of this report).

**3.03** **Classification of soils and susceptibility to liquefaction:** Results of the Particle Size Distribution, Atterberg Limits and Moisture Content are summarised as follows.

| | Clay Content (0.005mm passing as per USBR (a) definition) obtained from Particle Size Distribution Test | Atterberg Limits | | Maximum Moisture Content% |
|---|---|---|---|---|
| | | Liquid Limit (WL) % | Plastic Limit (PL) % | |
| Within Embankment | - | 44 | 17 | 22.1 |
| Natural Soil | 49 | 46 | 16 | 31.4 |

As per the ANCOLD Guidelines (Refer Fig 11 of this report) the soils tested lie outside the potentially liquefiable soils. Also the criteria for non-liquefiable soils as indicated in ANCOLD guidelines ie Clay Content >20% is satisfied.

Water Content < 0.9 (Liquid Limit) is satisfied by the tested clay samples and thus it is concluded that the clays are not susceptible to liquefaction. Given the subsurface profile comprising clayey soils, the embankment or the floor of the retarding basin is not susceptible to liquefaction. As per the ANCOLD guidelines, for the embankments not susceptible to liquefaction, dynamic deformations should not be a problem and initial screening assessment (detailed in 6.3.1 of ANCOLD guidelines) is required. The initial assessment based on our stability assessment and recommendations given in this report is analysed as follows.

**Initial Screening**

| Criteria given in the guidelines | **Subsurface profile and recommendations** | **Comments** |
|---|---|---|
| **1a** Compaction of the dam (densely compacted)<br><br>**1b** Peak accelerations at the base of the dam are 0.2g(gravity) or less; or the dam is constructed of clay soils, is on clay or rock foundations and peak accelerations are 0.35g or less | Due to the age of the dam and apparent density at the time of the investigation it is assumed the dam is satisfactorily compacted given its height<br><br>The dam is constructed on clay soils | |
| **2** The slopes of the dam are 3:1(H:V) or flatter | The batter slopes are approximately 1:1 (H:V) and should be extended out horizontally to satisfy this criterion | Criteria given in the ANCOLD guidelines are satisfied on the assumption that recommendations are carried out accordingly |
| **3** The static factors of safety of the critical failure surfaces involving loss of crest elevation , (ie other than the infinite slope case) are greater than 1.5 under loading conditions expected prior to an earthquake | Extending out the batter slopes to the required 3:1 (H:V) dimensions will likely increase the static factor of safety above 1.5 | |
| **4** The freeboard at the time of the earthquake is a minimum of 2 to 3 percent of the embankment height (not less than three feet (0.9m) . Fault displacement and reservoir seiches with regard to freeboard should be considered as separate problems | The freeboard at the time of the investigation was 1.0m in the most critical areas although this should be verified | |

**Note: This ANCOLD assessment is a preliminary assessment aimed to provide basic insight into the current condition of the embankments. As such no slope stability analysis has been performed.**

**3.04** **<u>Piping Failure:</u>** The clays are potentially dispersive as classified by the Emerson Dispersion tests. This along with the vegetation throughout the embankment may give rise to ‘piping’ type failures. It is also noted that due to the length of the embankments, the limited number of boreholes and the unsubstantiated compaction methods there is also potential for lower levels of compaction throughout the dam which would also increase the susceptibility to piping failure. The implementation of a geotextile may significantly reduce this potential.

**3.05** **General:** Conditions may change with the seasons. In particular, the surface soils and residual clays underlying the site at shallow depths may become saturated and unworkable following prolonged periods of rainfall.

The above recommendations are based on the test results, together with experience of similar conditions and are expected to be typical of the area or areas being considered. Nevertheless, all excavations should be examined carefully and any unusual feature reported to us in order to determine whether any changes might be advisable.

Under no circumstance should this report be reproduced unless in full.

T.J. HOLT MIEAust CPEng EC-1022
A.S. JAMES PTY LTD
X:\ Paddy\Commercial\118458 – Minta Farm Wetlands BERWICK\118458 – Minta Farm Wetlands STR.docx


A.S. JAMES PTY LTD
Geotechnical Engineers

**JOB:** MINTA FARM WETLANDS

**JOB No:** 118458 **DATE:** OCT '17

**LEGEND**

Denotes approximate borehole location

**BORE PLAN**

**CHECKED:** T. Holt
**DRAWN:** P. Beasley

SOURCE: GOOGLE EARTH

**FIGURE 1**

**A.S.JAMES PTY. LTD.**
**Geotechnical Engineers**

**Location:** Minta Farm Wetlands **Borehole** 1

**Job No.** 118458 **Date:** Oct '17

Ground Water: 4.5m

| Soil Type | Description | Depth | Tests | Results |
|---|---|---|---|---|
| | | 0.00 | | |
| FILL | Clay | | | |
| | Brown Mottled Orange | | | |
| | With Sand, With Silt | | s | 130 kPa |
| | Dry to Moist | | | |
| | Very Stiff | | | |
| | | | w | 17.0% |
| | | | s | 130 kPa |
| | | | s | 136 kPa |
| | | | w | 22.1% |
| | Tending Moist and Firm 3.0m | 3.00 | + | 2 / 4 / 5 |
| | | | | N = 9 |
| | | 3.70 | | |
| CLAY (CL) | Grey | | | |
| | Silty | | | |
| | Moist | | | |
| | Firm | | | |
| | Trace Organics Above 4.0m | | + | 2 / 2 / 3 |
| | | | | N = 5 |
| | BOREHOLE TERMINATED | 5.00 | | |

| | | |
|---|---|---|
| + Standard Penetration Test - N blows/150mm. incr. | c Apparent Cohesion | L.L. Liquid Limit |
| I Undisturbed Sample - Diameter Stated | Ø Friction Angle | P.L. Plastic Limit |
| s Vane Shear Strength | P Wet Density | P.I. Plasticity Index |
| p Pocket Penetrometer Resistance | w Moisture Content | L.S. Linear Shrinkage |

**Figure 2**

**A.S.JAMES PTY. LTD.**
**Geotechnical Engineers**

**Location:** Minta Farm Wetlands **Borehole** 2

**Job No.** 118458 **Date:** Oct '17

Ground Water: 4.5m

| Soil Type | Description | Depth | Tests | Results |
|---|---|---|---|---|
| | | 0.00 | | |
| FILL | Clay | | | |
| | Brown Mottled Orange | | | |
| | Sandy | | s | 70 kPa |
| | Dry to Moist | | | |
| | Stiff | | | |
| | | | s | 100 kPa |
| | | | s | 88 kPa |
| | | 2.50 | | |
| | | | w | 31.4% |
| | | | + | 2 / 2 / 3 |
| | | | | N = 5 |
| CLAY (CL) | Grey | | | |
| | Sandy | | | |
| | Moist tending Wet at Depth | | | |
| | Firm | | | |
| | With Organics above 4.0m | 4.00 | | |
| | | | w | 26.0% |
| | | | + | 2 / 2 / 5 |
| | | | | N = 7 |
| | | 5.50 | | |
| CLAY | Grey | | | |
| (CL/SC) | Very Sandy | | + | Sunk 450mm under SPT weight |
| | Wet, Very Soft | | | |
| | | 6.50 | | |
| CLAY (CL) | Grey | | | |
| | Sandy | | | |
| | Wet | | | |
| | Firm | | | |
| | BOREHOLE TERMINATED | 7.50 | w | 29.4% |

| | | |
|---|---|---|
| + Standard Penetration Test - N blows/150mm. incr. | c Apparent Cohesion | L.L. Liquid Limit |
| I Undisturbed Sample - Diameter Stated | Ø Friction Angle | P.L. Plastic Limit |
| s Vane Shear Strength | P Wet Density | P.I. Plasticity Index |
| p Pocket Penetrometer Resistance | w Moisture Content | L.S. Linear Shrinkage |

**Figure 3**

**A.S.JAMES PTY. LTD.**
**Geotechnical Engineers**

**Location:** Minta Farm Wetlands **Borehole** 3

**Job No.** 118458 **Date:** Oct '17

Ground Water: 4.5m

| Soil Type | Description | Depth | Tests | Results |
|---|---|---|---|---|
| | | **0.00** | | |
| | | | s | 120 kPa |
| FILL | Clay | | | |
| | Grey Brown Mottled Orange | | | |
| | Sandy | | w | 13.0% |
| | Dry | | s | 126 kPa |
| | Very Stiff | | | |
| | | | s | 120 kPa |
| | | | w | 21.6% |
| | Tending Moist and Firm | **3.00** | + | 2 / 3 / 4 |
| | | | | N = 7 |
| | | **3.30** | | |
| CLAY (CL) | Grey | | | |
| | Sandy | | | |
| | Moist, Tending Wet at Depth | | | |
| | Firm | | | |
| | | | w | 27.6% |
| CLAY | Grey | **4.50** | + | Sunk 300mm / 2 |
| (CL/SC) | Very Sandy | | | N = 2 |
| | Wet, Soft | | | |
| | BOREHOLE TERMINATED | **5.00** | | |

| | | | |
|---|---|---|---|
| + Standard Penetration Test - N blows/150mm. incr. | c Apparent Cohesion | L.L. Liquid Limit | **Figure 4** |
| I Undisturbed Sample - Diameter Stated | Ø Friction Angle | P.L. Plastic Limit | |
| s Vane Shear Strength | P Wet Density | P.I. Plasticity Index | |
| p Pocket Penetrometer Resistance | w Moisture Content | L.S. Linear Shrinkage | |

**A.S.JAMES PTY. LTD.**
**Geotechnical Engineers**

**Location:** Minta Farm Wetlands **Borehole** 4

**Job No.** 118458 **Date:** Oct '17

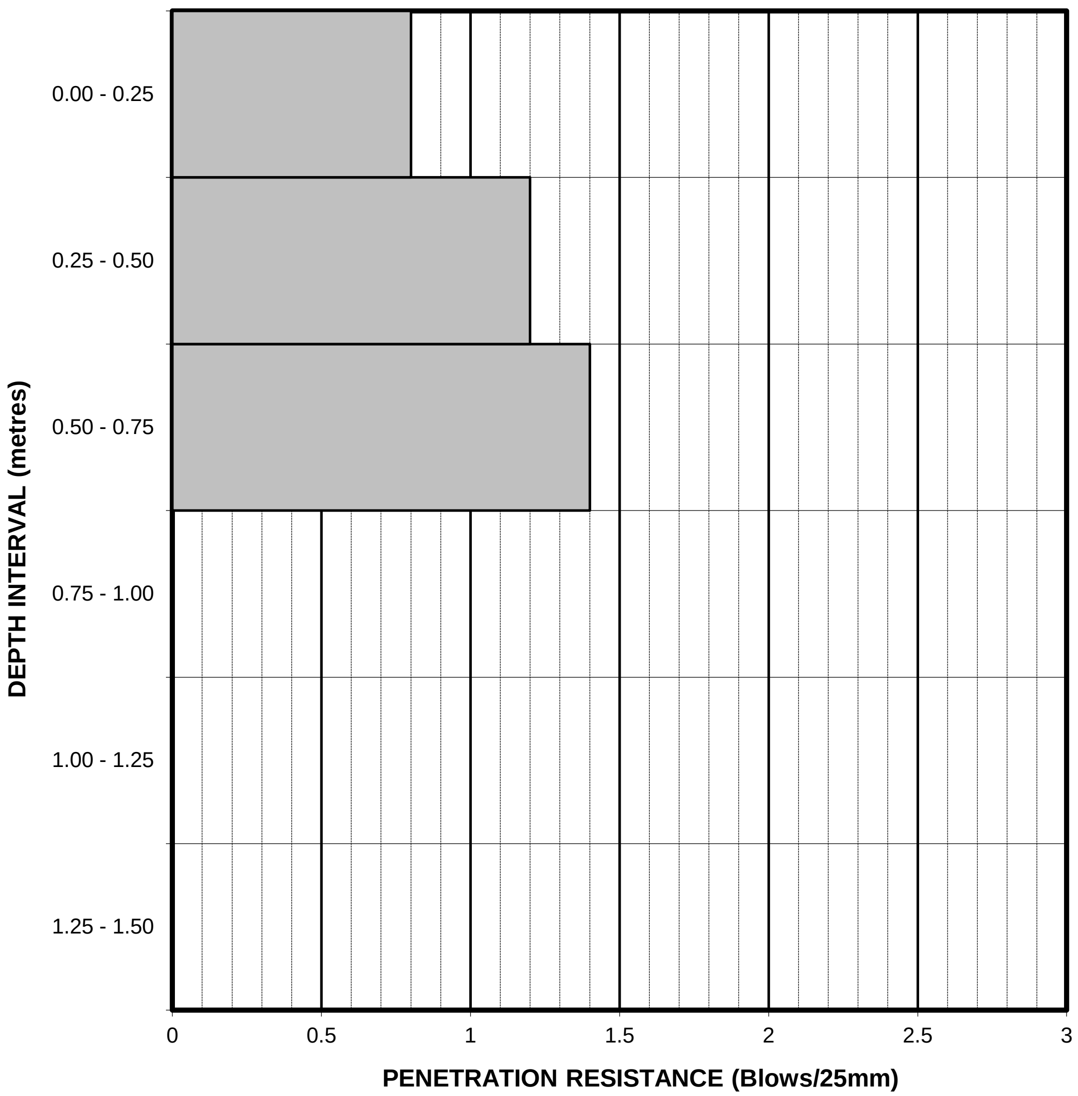
Ground Water: NIL

| Soil Type | Description | Depth | Tests | Results |
|---|---|---|---|---|
| | | **0.00** | | |
| FILL | Clay | | | |
| | Brown | | **s** | 100 kPa |
| | Sandy, Silty | | | |
| | Dry | | | |
| | Stiff | | **w** | 18.8% |
| | | | **s** | 126 kPa |
| | | **1.50** | **s** | 80 kPa |
| | Very Silty Lens from 1.5 - 2.0 Metres | | | |
| | | **2.00** | | |
| | | **2.70** | | |
| CLAY (CL) | Grey Mottled Brown | | **w** | 29.7% |
| | Sandy | | **+** | 3 / 3 / 5 |
| | Moist | | | N = 8 |
| | Firm | | | |
| | BOREHOLE TERMINATED | **3.50** | | |

| | | | |
|---|---|---|---|
| + Standard Penetration Test - N blows/150mm. incr. | c Apparent Cohesion | L.L. Liquid Limit | **Figure 5** |
| I Undisturbed Sample - Diameter Stated | Ø Friction Angle | P.L. Plastic Limit | |
| s Vane Shear Strength | P Wet Density | P.I. Plasticity Index | |
| p Pocket Penetrometer Resistance | w Moisture Content | L.S. Linear Shrinkage | |

| A.S. JAMES PTY LTD Geotechnical Engineers | **JOB:** MINTA FARM WETLANDS | **JOB No.** 118458 |
|---|---|---|
| | | **DATE:** Oct '17 |

DEPTH BELOW GROUND SURFACE AT THE COMMENCEMENT OF PENETRATION: 0.0 METRE

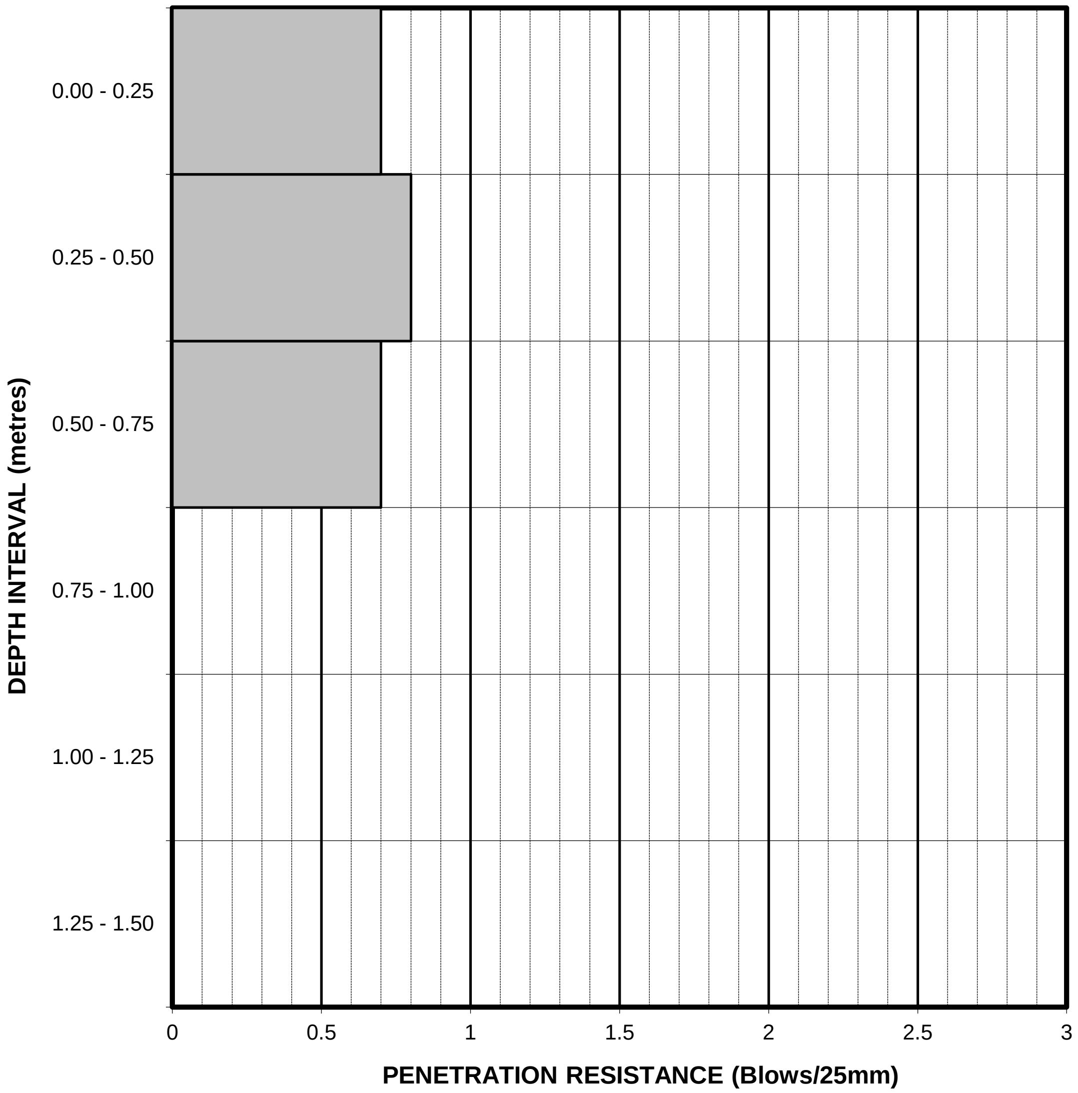



**TEST LOCATION: ADJACENT TO BOREHOLE NO. 1 ( REFER TO FIGURE 1 )**

| **DYNAMIC CONE PENETROMETER TEST (AS1289, 6.3.2, 1997)** | **Drawn / Tested:** P. Beasley | **Figure** |
|---|---|---|
| 325 sq.mm Cone - 9 kg Weight Falling 510 mm | **Checked:** T. Holt | **6** |

| A.S. JAMES PTY LTD Geotechnical Engineers | JOB: MINTA FARM WETLANDS | JOB No. 118458 |
|---|---|---|
| | | DATE: Oct '17 |

DEPTH BELOW GROUND SURFACE AT THE COMMENCEMENT OF PENETRATION: 0.0 METRE

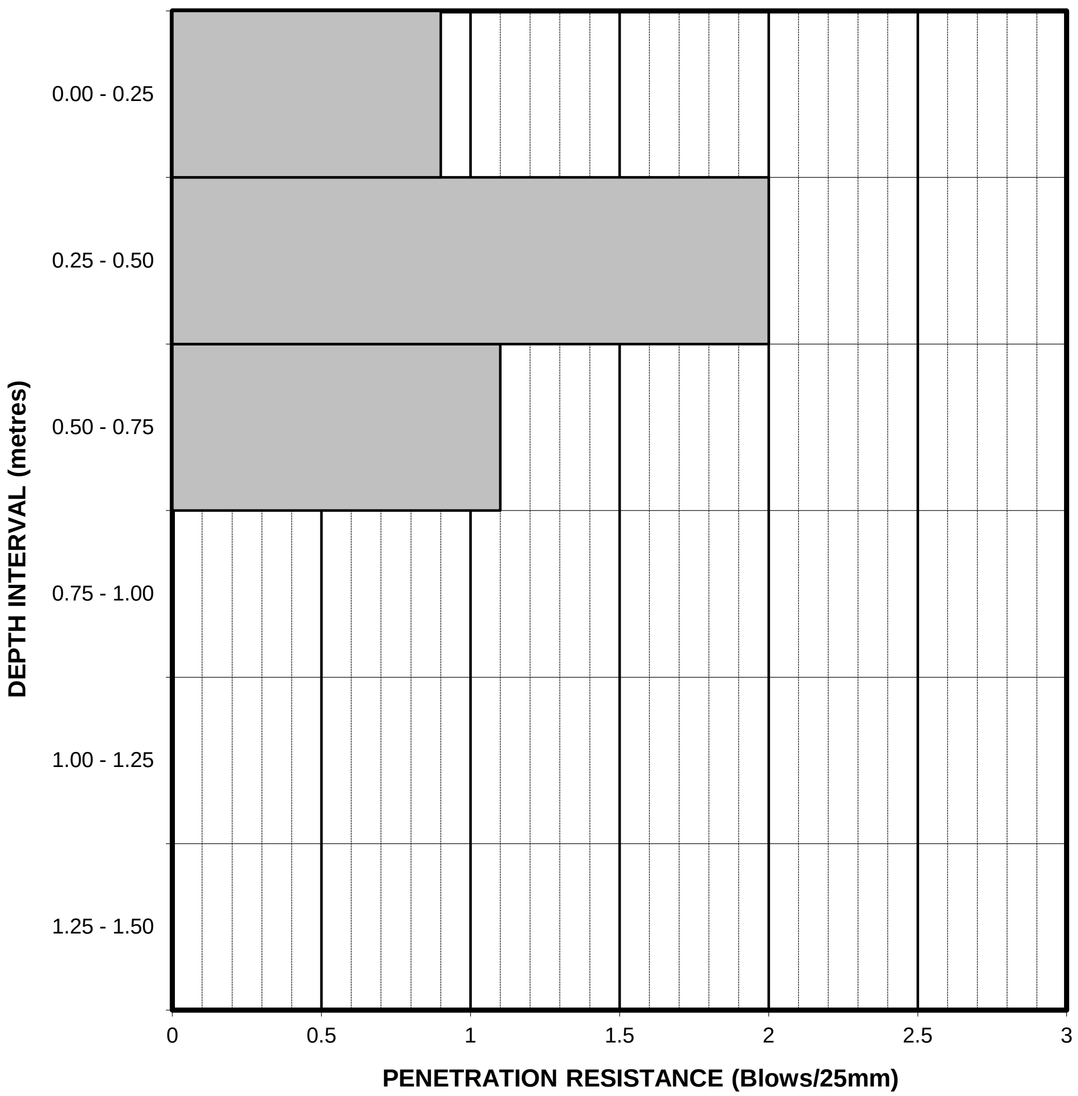



**TEST LOCATION: ADJACENT TO BOREHOLE NO. 2 ( REFER TO FIGURE 1 )**

| DYNAMIC CONE PENETROMETER TEST (AS1289, 6.3.2, 1997) | Drawn / Tested: P. Beasley | Figure |
|---|---|---|
| 325 sq.mm Cone - 9 kg Weight Falling 510 mm | Checked: T. Holt | 7 |

| A.S. JAMES PTY LTD<br>Geotechnical Engineers | **JOB:** MINTA FARM WETLANDS | **JOB No.** 118458<br>**DATE:** Oct '17 |
|---|---|---|

DEPTH BELOW GROUND SURFACE AT THE COMMENCEMENT OF PENETRATION: 0.0 METRE

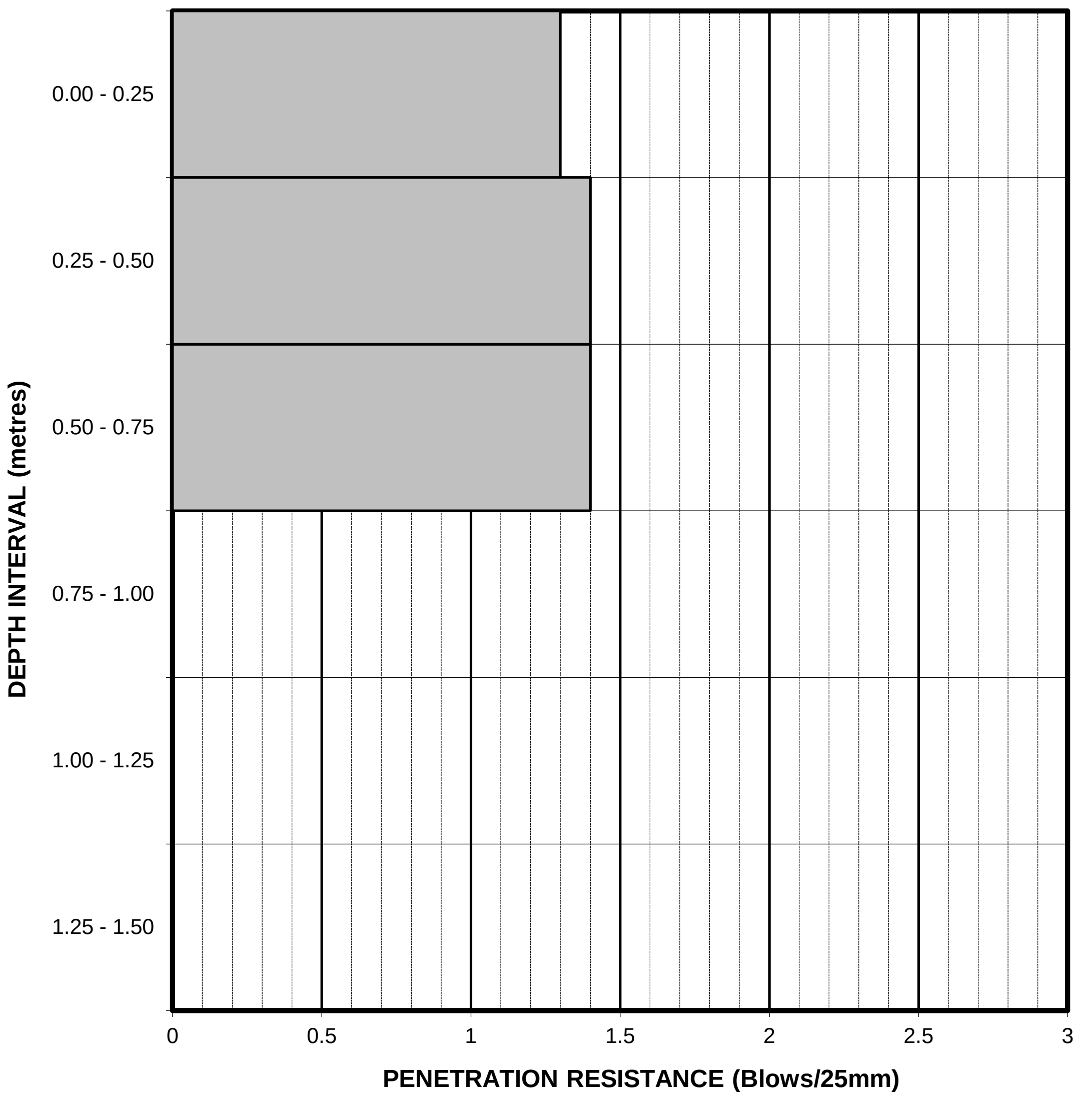



**TEST LOCATION: ADJACENT TO BOREHOLE NO. 3 ( REFER TO FIGURE 1 )**

| **DYNAMIC CONE PENETROMETER TEST (AS1289, 6.3.2, 1997)**<br>325 sq.mm Cone - 9 kg Weight Falling 510 mm | **Drawn / Tested:** P. Beasley<br>**Checked:** T. Holt | **Figure**<br>**8** |
|---|---|---|

| A.S. JAMES PTY LTD Geotechnical Engineers | JOB: MINTA FARM WETLANDS | JOB No. 118458 |
|---|---|---|
| | | DATE: Oct '17 |

DEPTH BELOW GROUND SURFACE AT THE COMMENCEMENT OF PENETRATION: 0.0 METRE




**TEST LOCATION: ADJACENT TO BOREHOLE NO. 4 ( REFER TO FIGURE 1 )**

| DYNAMIC CONE PENETROMETER TEST (AS1289, 6.3.2, 1997) | Drawn / Tested: P. Beasley | Figure |
|---|---|---|
| 325 sq.mm Cone - 9 kg Weight Falling 510 mm | Checked: T. Holt | 9 |

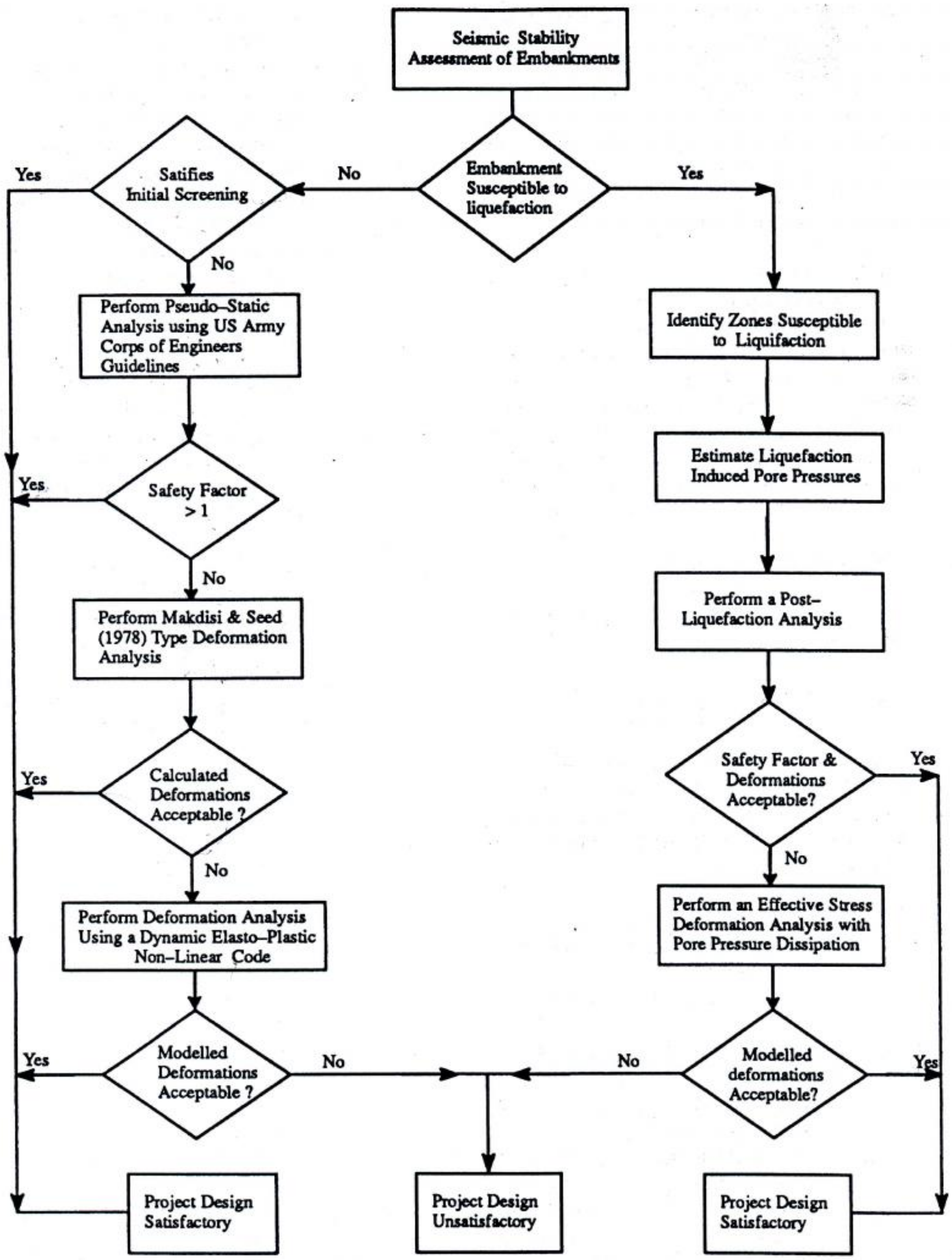
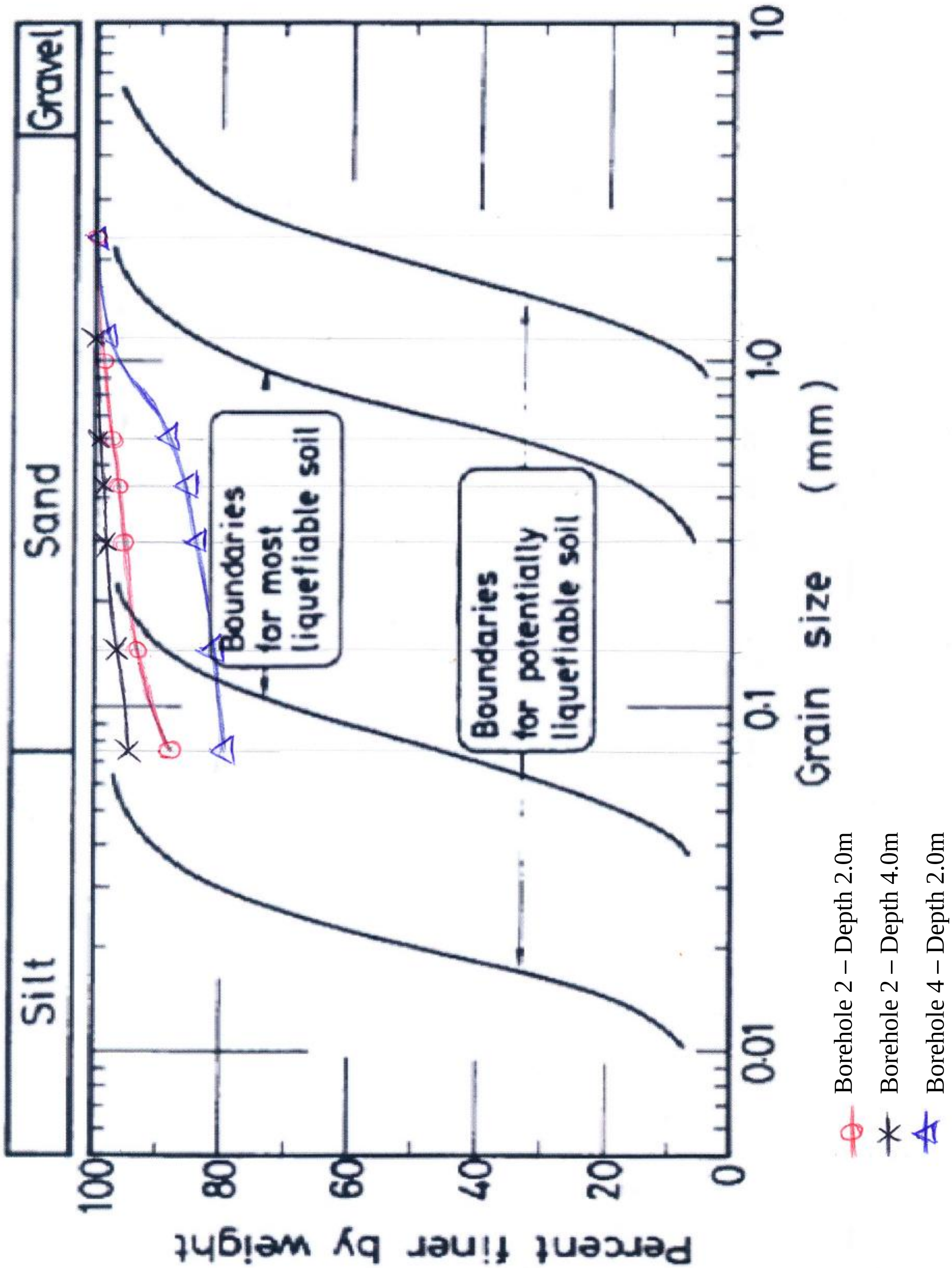



Figure 32. Embankment seismic stability assessment chart.



**EMBANKMENT SEISMIC STABILITY ASSESSMENT CHART**

| **A.S. JAMES PTY LTD** Geotechnical Engineers | **JOB:** Minta Farm Wetlands | **JOB No.** 118458 |
|---|---|---|
| | | **DATE:** Oct ‘ 17 |




| **Limits in the Gradation Curves separating most liquefiable soils and potentially liquefiable soils** | **Figure** 11 |
|---|---|

# APPENDIX 1

***Laboratory Test Results***

| A.S. JAMES PTY.LTD<br>Geotechnical Engineers<br>Clayton Laboratory<br>15 Libbett Av Clayton South | JOB: Minta Farms<br>Wetlands | JOB No. 118458<br>REPORT No: L001<br>DATE: 7-Oct-17 |
|---|---|---|

FOR
Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121

| Test | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Lab Sample No. | 59142 | 59143 | 59144 | |
| Location | Bore Hole 2 | Bore Hole 2 | Bore Hole 4 | |
| Depth (m) | 2.0 | 4.0 | 2.0 | |
| Sample Description | CLAY, Silty, Grey with Yellow Brown | SILT, Clayey, Grey | SILT, Clayey, Grey Brown | |
| Condition | | | | |
| Preparation | | | | |

| Aperture Size mm | Grading of Samples % Passing | | | |
|---|---|---|---|---|
| 75.0 | 100 | 100 | 100 | |
| 53.0 | 100 | 100 | 100 | |
| 37.5 | 100 | 100 | 100 | |
| 26.5 | 100 | 100 | 100 | |
| 19.0 | 100 | 100 | 100 | |
| 13.2 | 100 | 100 | 100 | |
| 9.5 | 100 | 100 | 100 | |
| 6.7 | 100 | 100 | 100 | |
| 4.75 | 100 | 100 | 100 | |
| 2.36 | 100 | 100 | 100 | |
| 1.18 | 99 | 100 | 98 | |
| 0.600 | 97 | 99 | 88 | |
| 0.425 | 96 | 98 | 85 | |
| 0.300 | 95 | 97 | 83 | |
| 0.150 | 92 | 96 | 80 | |
| 0.075 | 86 | 94 | 79 | |

| | Plastic Index of Samples % | | | |
|---|---|---|---|---|
| Liquid Limit | | | | |
| Plastic Limit | | | | |
| Linear Shrinkage | | | | |
| Shrinkage Behaviour | | | | |
| Plasticity Index | | | | |

NATA

Accredited for compliance with ISO/IEC 17025 - Testing
Accreditation No. 934

Approved Signatory
B.McFarlane (Dip Lab Tech.) 7-Oct-17

Notes:

Testing Carried Out On Samples As Supplied

| REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS & PLASTIC LIMITS<br>AS PER AS1289 .1.1, 2.1.1,3.6.1,<br>A.S.JAMES FORM No: LR007A1 (Fig 1) / REV 0 / 30/3/17 | Tested By : Y.Singh<br>Reported By : B.McFarlane | Figure<br>1 of 1 |
|---|---|---|

| A.S. JAMES PTY.LTD Geotechnical Engineers Clayton Laboratory 15 Libbett Av Clayton South | JOB: Minta Farms Wetlands | JOB No. 118458 REPORT No: L001-1 DATE: 7-Oct-17 |
|---|---|---|

**FOR** Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121

| Test | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Lab Sample No. | 59145 | 59146 | | |
| Location | Bore Hole 1 | Bore Hole 3 | | |
| Depth (m) | 2.0 | 4.5 | | |
| Sample Description | CLAY, Silty, Sandy, Dark Grey with Orange Brown | CLAY, Silty, Grey with Orange Brown | | |
| Condition | Oven Dried < 50 Deg | Oven Dried < 50 Deg | | |
| Preparation | Dry Sieved | Dry Sieved | | |

| Aperture Size mm | Grading of Samples % Passing | | | |
|---|---|---|---|---|
| 75.0 | | | | |
| 53.0 | | | | |
| 37.5 | | | | |
| 26.5 | | | | |
| 19.0 | | | | |
| 13.2 | | | | |
| 9.5 | | | | |
| 6.7 | | | | |
| 4.75 | | | | |
| 2.36 | | | | |
| 1.18 | | | | |
| 0.600 | | | | |
| 0.425 | | | | |
| 0.300 | | | | |
| 0.150 | | | | |
| 0.075 | | | | |

**Plastic Index of Samples %**

| | | | | |
|---|---|---|---|---|
| Liquid Limit | 44 % | 46 % | | |
| Plastic Limit | 17 % | 16 % | | |
| Linear Shrinkage | 11 % | 11 % | | |
| Shrinkage Behaviour | Slight Curling | Normal | | |
| Plasticity Index | 27 % | 30 % | | |

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Accreditation No. 934

Approved Signatory
B.McFarlane (Dip Lab Tech.) 7-Oct-17

Notes:

Testing Carried Out On Samples As Supplied

| REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS & PLASTIC LIMITS AS PER AS1289 .1.1, 2.1.1,3.1.2,3.2.1,3.3.1,3.4.1, A.S.JAMES FORM No: LR007A1 (Fig 1) / REV 0 / 30/3/17 | Tested By : D.Vuarchoz<br>Reported By : B.McFarlane | Figure<br>1 of 1 |
|---|---|---|

| **A.S. JAMES** PTY. LTD. Geotechnical Engineers Clayton Laboratory 15 Libbett Av Clayton South | **JOB:** MINTA FARMS WETLANDS | **JOB No:** 118458 **REPORT No:** L001-2 **DATE:** 07-Oct-17 |
|---|---|---|

**FOR** Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121

| | | |
|---|---|---|
| Date Sampled: | 3-Oct-17 | 3-Oct-17 |
| Lab Sample Number: | 59147 | 59148 |
| Sample Location: | Bore Hole 1 | Bore Hole 2 |
| Sample Depth: (m) | 2.0 | 1.0 |
| Sample Description: | CLAY, Silty, Grey & Yellow Brown | CLAY, Silty, Grey & Yellow Brown |
| Type Of Water Used: | PURE | PURE |
| **EMERSON CLASS NUMBER** | **2** | **2** |

NATA Accredited for compliance with ISO/IEC 17025 - Testing
Accreditation No. 934

APPROVED SIGNATORY

B.McFarlane (Dip Lab Tech.) 07-Oct-17

Testing carried out on samples as supplied

| | | |
|---|---|---|
| DETERMINATION OF THE EMERSON CLASS NUMBER OF A SOIL<br>AS PER AS 1289.1.1,3.8.1,<br>A.S.JAMES FORM No: LR018 (Fig 1) / REV 10 / 10/06/17 | TESTED : S.Bailey<br>REPORTED : B.McFarlane | FIGURE<br>1 of 1 |

| | | |
|---|---|---|
| **A.S. JAMES** PTY. LTD.<br>**Geotechnical Engineers**<br>**Clayton Laboratory**<br>**15 Libbett Av Clayton South** | **JOB:**<br>Minta Farms<br>Wetlands | **JOB No.** 118458<br>**REPORT No.** L001-3<br>**DATE.** 07-Oct-17 |

**FOR**
Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121

| Lab Sample No. | Soil Description | Sample Location | Depth of Sample (m) | Insitu Moisture Content ( % ) |
|---|---|---|---|---|
| 59149 | CLAY, Silty, Orange Brown & Grey | Bore Hole 1 | 1.00 | 17.0 |
| 59150 | CLAY, Orange Brown & Grey | Bore Hole 1 | 3.00 | 22.1 |
| 59151 | CLAY, Silty, Sandy, Dark Grey | Bore Hole 2 | 3.00 | 31.4 |
| 59152 | CLAY, Silty, Dark Grey | Bore Hole 2 | 4.50 | 26.0 |
| 59153 | Clay, Silty Grey | Bore Hole 2 | 7.50 | 29.4 |
| 59154 | CLAY, Silty, Brown & Orange Brown | Bore Hole 3 | 1.00 | 13.0 |
| 59155 | CLAY, Silty, Grey Brown | Bore Hole 3 | 3.00 | 21.6 |
| 59156 | CLAY, Silty, Sandy, Yellow Brown & Grey | Bore Hole 3 | 4.50 | 27.6 |
| 59157 | CLAY, Silty, Yellow Brown & Grey | Bore Hole 4 | 1.00 | 18.8 |
| 59158 | CLAY, Silty, Grey to Dark Grey | Bore Hole 4 | 3.00 | 29.7 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**NOTES:** Testing Carried Out On Samples As Supplied

NATA

Accredited for compliance with ISO/IEC 17025 - Testing
Accreditation No. 934

APPROVED SIGNATORY B.McFarlane (Dip Lab Tech.) 07-Oct-17

| | | |
|---|---|---|
| Soil moisture content tests - Determination of the moisture content of a soil -<br>AS PER AS1289 .1.1,2.1.1,<br>A.S.JAMES FORM No: LR014 (Fig 1) / REV 10 / 10/01/17 | TESTED : B.McFarlane<br>REPORTED : B.McFarlane | FIGURE<br>1 of 1 |

| A.S. JAMES PTY.LTD<br>Geotechnical Engineers<br>Clayton Laboratory<br>15 Libbett Av Clayton South | JOB:<br>Minta Farms<br>Wetlands | JOB No. 118458<br>REPORT No: L002<br>DATE: 21-Oct-17 |
|---|---|---|

**Client Details:**

Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121

**Lab Sample No.** 51681
**Sample Location** Bore Hole 2
**Sample Depth (m)** 3.0
**Type of Hydrometer** g/l
**Sample Description** Clay / Silt - Sandy Dark Gey
**Pretreated** No
**Loss in Pretreatment (%)**
**Dispersion Method** Inversion

## Sieve Analysis

| Aperture Size | 75.0 | 53.0 | 37.5 | 26.5 | 19.0 | 13.2 | 9.5 | 6.7 | 4.75 | 2.36 | 1.18 | 0.600 | 0.425 | 0.300 | 0.150 | 0.075 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % passing Sample | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 98 | 96 | 92 | 86 |

## Hydrometer Analysis

| Particle Size (um) | 73 | 52 | 37 | 26 | 18 | 13 | 9 | 7 | 5 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % Passing Sample | 86 | 78 | 70 | 67 | 67 | 61 | 59 | 55 | 49 | 47 | 43 | 41 |

## Plastic Index of Sample

| Sample Condition | |
|---|---|

| Sample Preparation | |
|---|---|

| Lab Sample No | Liquid Limit | Plastic Limit | Linear Shrinkage | Shrinkage Behavior | Plastic Index |
|---|---|---|---|---|---|
| | | | | | |

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Accreditation No. 934

Approved Signatory
21-Oct-17
S.Bailey (Dip Lab Tech.)

**NOTES:** Testing Carried Out On Samples As Supplied

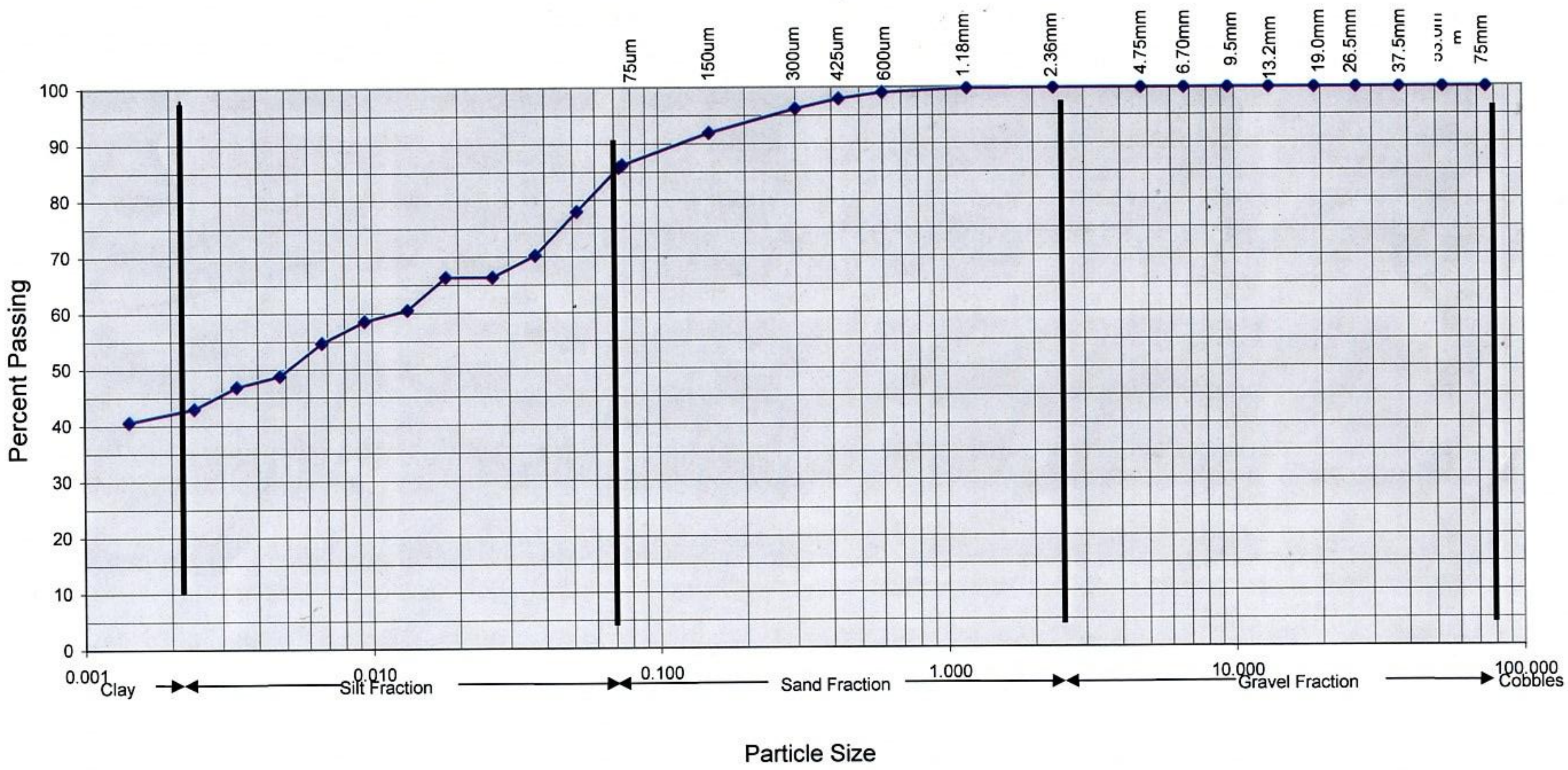
| REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS, HYDROMETER ANALYSIS & PLASTIC LIMITS<br>AS PER AS1289 .1.1, 3.6.1,3.6.3,<br>A.S.JAMES FORM No: LR007, Fig 1, REV 10 , 10/01/17 | Tested By : S.Bailey<br>Checked By : S.Bailey | Figure<br>1 of 1 |
|---|---|---|

**A.S. JAMES** PTY.LTD

Geotechnical Engineers
Clayton Laboratory
15 Libbett Av Clayton South

| JOB: | JOB No. | 118458 |
|---|---|---|
| Minta Farms | REPORT No: | L002 |
| Wetlands | DATE: | 21-Oct-17 |

**Client Details** Alluvium
Level 1, 105-115 Dover Street
CREMORNE, VIC. 3121




NATA Accredited for compliance with ISO/IEC 17025 - Testing
Accreditation No. 934

Approved Signatory
S.Bailey (Dip Lab Tech.)
21-Oct-17

| REPORT OF TEST RESULTS ON SOILS - SIEVE ANALYSIS, HYDROMETER ANALYSIS & PLASTIC LIMITS<br>AS PER AS1289 .1.1, 3.6.1,3.6.3,<br>A.S.JAMES FORM No: LR007 Fig 2 , REV 7, 10/01/17 | Tested By : S.Bailey<br>Checked By : S.Bailey | Figure<br>2 of 2 |
|---|---|---|