Stormy Water Solutions

AND

Neil M Craigie Pty Ltd

Berwick Waterways

Summary Issues Paper

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Report by:

Valerie Mag BE Civil (Hons), M Eng Sci
Stormy Water Solutions
stormywater@optusnet.com.au
Ph 9511 5911, M 0412 436 021

Neil Craigie BE(Civil),
MEngSci, MIEAust, CPEng
Neil. M Craigie Pty Ltd
nmcraigie@bigpond.com
Telephone & Fax: (03) 9725 1053

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1. Introduction

Berwick Waterways refers to a study area that is currently zoned for rural living development in Berwick. The area is also known as the Homestead Road Extension Development Services Scheme (DSS) by Melbourne Water Corporation (MWC). There have been various studies aimed at facilitating rezoning of the area for residential purposes over many years.

The area is bounded by the levee banks of Hallam Valley Contour Drain and Berwick Town Drain to the west, Greaves Road to the south and existing residential development to the east and north.

Much of the land is flood prone. Rezoning of the area will require significant drainage infrastructure. MWC have identified the requirement of a linear wetland and filling of land to facilitate development. However, fragmented ownership means that implementation of the required drainage infrastructure would need to be appropriately coordinated.

In an effort to create some level of certainty regarding development of the site, Council Officers prepared the Berwick Waterways Development Plan in 2007. The purpose of the plan was to ensure equitable coordination of infrastructure elements across the various landowners, and identify connector roads, transport routes, local facilities and open spaces.

A major obstacle to rezoning is the acquisition and maintenance of the land required for drainage. In April of 2008, Melbourne Water agreed to purchase the land required for the wetland-floodway (i.e. drainage) corridor through Berwick Waterways, on the condition that Council can demonstrate development for urban purposes is viable given the very high cost of providing the infrastructure.

Council subsequently commissioned Charter Keck Cramer (CKC) to review development feasibility based on parameters set by a Concept Plan prepared by Tract Consultants, which was the basis for the preparation of the 2007 Berwick Waterways Development Plan. The Charter Keck Cramer report indicated that development viability was marginal. As such, Melbourne water is not willing to commit to land acquisition at this stage.

To enable future development of the area, further investigation and conceptual planning is required to overcome factors limiting feasibility, and address Melbourne Water’s concerns. Therefore the Growth Areas Authority (GAA) has engaged Stormy Water Solutions and Neil M Craigie Pty Ltd to conduct an investigation to enable:

- cost effective development of Berwick Waterways; and,
- coordinated and equitable delivery of drainage infrastructure.

The specific objectives of this project are to:

- Minimise or eradicate requirements for fill over future housing development areas,
- Maintain the peak flow capacity required by Melbourne Water for stormwater management,
- Minimise the land-take required to accommodate required drainage infrastructure (unless such land-take can facilitate a net increase in financial value),
- Enhance treatment of water passing through the site, to reduce the nutrient levels discharging further downstream in accordance with Melbourne Water standards,
- Limit impact on properties where existing land uses may persist for the foreseeable future (e.g. Buddhist Temple),
- Maximise the amenity and usability of any open waterways or retarding basins to integrate with development and contribute to the financial and community value of the development, and
- Determine an appropriate staging strategy that will permit development over time with minimal impost to landowners, Melbourne Water and the City of Casey.

This report is the first report which will be produced for the project. It specifically:

- summarises the current drainage strategy for the area as documented within MWC's Homestead Road Extension DSS,
- details the history of drainage in the area,
- identifies issues and constraints in regard to the drainage infrastructure, and
- identifies possible changes to the current drainage strategy which could be utilised to meet some or all of the objectives described above.

Following this report, the GAA, MWC, City of Casey and the consultant team will workshop all issues identified. It is anticipated that at least 3 options will be identified for further investigation. The ultimate objective is to produce a drainage strategy which can meet all the drainage requirements while facilitating cost effective development of Berwick Waterways.

It should be noted that much of the content in this report is reproduced from previous reports.

- Homestead Road Drainage Area Study, Proposed Wetland Pondage System, Stage 2 Final Concept Design, Neil M Craigie and Pat Condina,31 January 2005, 10 August 2007
- Homestead Road Drainage Area Study, Proposed Wetland Pondage System, Executive Summary and Comments in Relation to 322-340 Centre Road, Berwick, Neil M Craigie, 10 August 2007
- Civil Engineering Development Cost Report, Proposed Residential Development, Berwick Waterways, Charter Keck Cramer, October 2008
- Homestead Road Drainage Requirements Study, Catchment No. 0613, Stormy Water Solutions for Melbourne Water Corporation, June 2004
- Berwick Waterways Development Plan, City of Casey, 4 March 2008

2. Site Area Description

2.1 Study Area Description

The study area is located west of the Homestead Road Development Services Scheme (DSS). The blue shaded area in Figure 1 is known as the Homestead Road Extension DSS by MWC. The study area entirely within the City of Casey. The study area is approximately 84 ha and is located in the flatter areas of the catchment.

Melbourne Water drainage scheme pipes service the existing development to the east, with small, flat open drains servicing the lower areas of the catchment. The catchment outfall is a syphon under the Hallam Valley Contour Drain levee. Due to the minimal slope of the open drain system though the flats, ongoing drainage problems occur in this area.

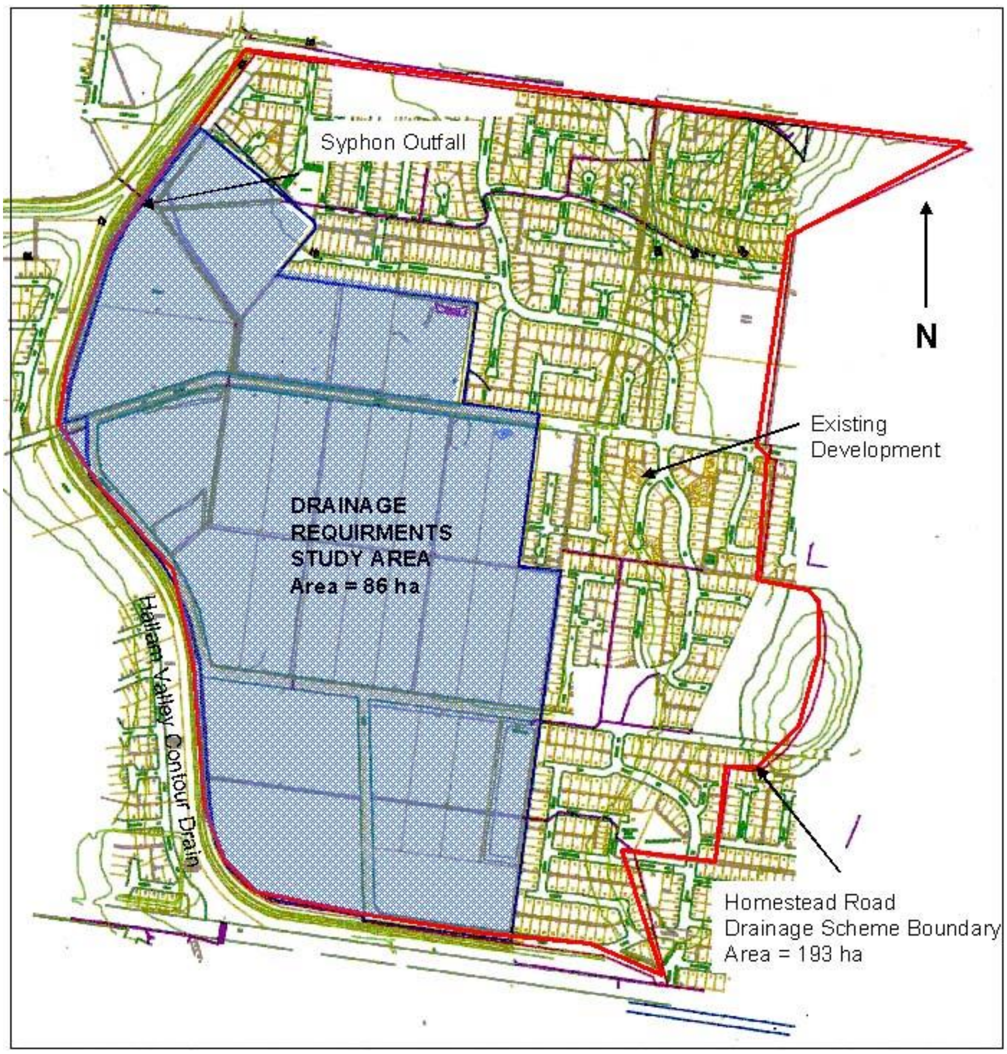

Figure 1. Berwick Waterways Study Area

The study area is currently zoned for Rural Living Zone development. The study area is bounded by the levee banks of Hallam Valley Contour Drain and Berwick Town Drain to the west, Greaves Road to the south and existing residential development to the east and north.

2.2 Drainage Form and History

The total catchment area at the catchment outlet in the north west corner of the site is 193 ha (Homestead Road DSS and Homestead Road Extension DSS). The outlet of the catchment is a syphon outlet and flood gate outlet at Berwick Town Drain.

The area was originally floodplain land subject to frequent inundation from the large Ti Tree Creek/Hallam Valley catchment. As such, the area is naturally wet and prone to waterlogging. The pre European form would have included extensive wetland features typified by melaleuca swamplands. There are no natural features or significant remnant vegetation left within the study area.

The land was first subdivided into allotments of between 12 and 20 acres after the First World War and parts between Centre Road and Homestead Road were further subdivided into lots between 4.75 and 6.5 acres in the 1960's.

High levee banks now separate the land from the main waterways (Hallam Valley Contour Drain and Berwick Town Drain). Poorly graded open drains provide a low level drainage service within Homestead Road Extension DSS. The form of drainage for the area is not conventional and is unique in the metropolitan context, as there is no natural drainage outlet, rather there is only the syphon outlet under the levee-banked Berwick Town Drain.

MWC have designated a 100 year ARI flood level for lands in the study area of 18.15 m AHD. MWC will not approve further filling of land below 18.15 m AHD as this will reduce the flood storage volume and increase local flood levels east and north of the leveed system (i.e. with in the study area). Higher flood levels apply in the Hallam Valley Contour Drain/Berwick Town Drain floodplains to the west of the confining levee banks, which define the westerly limit of the study area.

Due to very poor surface drainage gradients throughout the study area, additional filling (in excess of that required for flood protection) is required at locations removed from the main flood area so as to maintain satisfactory freeboard to drainage lines. At the present time MWC have specified a 600 mm freeboard requirement, which sets the minimum fill level of 18.65 m AHD. Additional fill in excess of this level is required to allow for lot and pipe drainage slopes to slope towards the drainage reserve. Also, all pipes require at least 600 – 750 mm cover to meet current MWC standards.

The Dandenong Valley Authority determined in the 1980's and early 1990's that the flat land adjacent to the Hallam Valley Contour Drain should be excluded from residential zoning in the past due to drainage difficulties. This decision was based on the assumption that any development would require a piped drainage outfall. With the advent of Water Sensitive Urban Deign (WSUD) and wetland innovations it is now considered that development can occur as detailed below.

However, even with a wetland facilitating drainage, there are still major difficulties associated with implementing a drainage strategy.

Landowners have petitioned council to rezone the area to residential housing. Rezoning cannot occur until existing flooding and drainage constraints can be overcome in an **economical** and **environmentally satisfactory** manner.

Council commissioned Neil M Craigie and Pat Condina to prepare the Stage Homestead Road Drainage Area Study in 2003. This work proposed a strategy based on construction of a major linear wetland and floodway system which would allow more intensive urban development to proceed whilst restoring extensive natural values and providing significant landscape interest and open space amenity for the local and wider community.

The Stage 2 of this work was completed in January 2005. It presented a final concept design for the floodplain wetland system. This wetland concept design now forms the basis for MWC's Homestead Road Extension DSS, prepared in a parallel study for MWC by Stormy Water Solutions.

This wetland proposal is described below.

3. Existing Drainage Strategy Proposal

It has been proposed to allow development within the DSS by incorporating an extensive wetland system within the DSS study area. This proposal will facilitate the development of approximately 61.5 ha of residential land and development of an extensive wetland system within approximately 24 ha of Public Open Space (i.e. wetland reserve, based on 2004 MWC DSS plan).

This concept was originally proposed by Neil Craigie and Pat Condina. It provides for:

- creation of continuous linear wetland/pool systems for management of stormwater quality from existing developed areas in both the Homestead Road and O'Sheas Road DSS catchments;
- incorporation of the existing MWC Homestead Road Retarding Basin as part of this system by removal of the existing embankments;
- use of the airspace above the water surface area and over the lands in the balance of the reserve area for flood storage purposes;
- wetlands and pools to replace all existing open drains within the study area, thereby resolving existing open drain performance and maintenance concerns;
- restoration of natural waterway and floodplain habitat values throughout the proposed reserve area;
- provision of a high value recreational corridor which will complete a missing link between the floodplain developments south of Greaves Road and those recently constructed by MWC adjacent to Golf Links Road west of the Berwick Town Drain.

The wetland concept was incorporated into the Homestead Road Extension DSS. Figure 2 shows the general arrangement of the Homestead Road Extension DSS, including the land proposed for further residential development and the land required for the wetland reserve. Figure 3 details the Concept Design for the wetland system developed by Neil Craigie and Pat Condina.

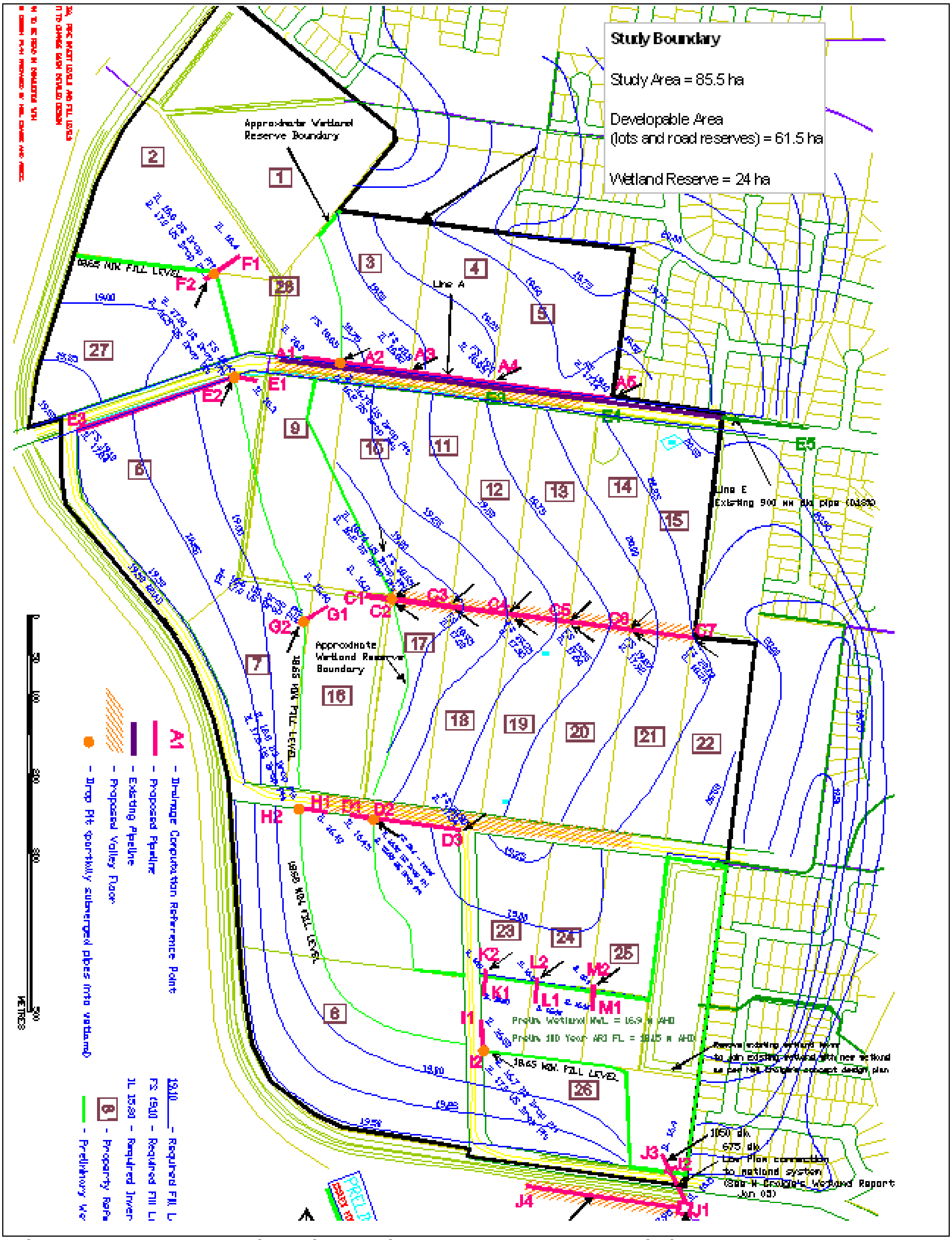

Figure 2 Homestead Road Extension DSS – Stormy Water Solutions 2004

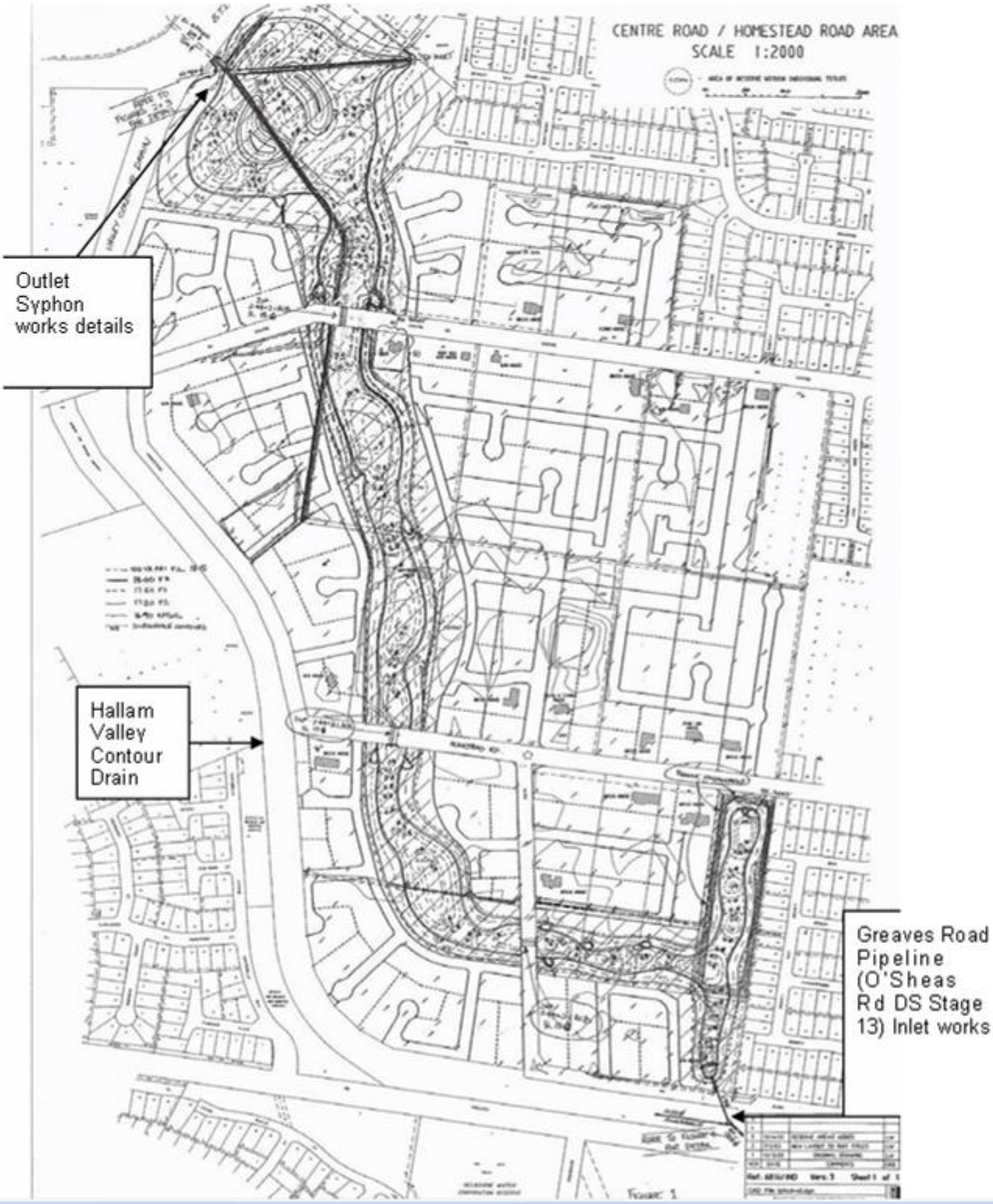

Figure 3 Berwick Waterways Wetland Concept Design – Neil Craigie and Pat Condina

The O'Sheas Road Drainage Scheme (336 ha catchment) has been included in the strategy. At present this catchment area receives virtually no water quality treatment. The Homestead Road area presents the only viable opportunity for treatment of this fully developed catchment. The current proposal provides for all flows up to 1 m^3/s to be directed from the Greaves Road pipeline into the Homestead Road floodplain wetland system.

The drainage system parameters for the current wetland and reserve are reiterated below.

- The total water surface area of the wetland pondage systems = 10.40 ha

- The normal top water level (NTWL) of the wetland pondage areas = 16.90 m AHD
- The 100 year ARI flood level = 18.15 m (≤ existing MWC declared level).
- 100 Year ARI flood area = 19.5 ha.
- 100 Year flood storage = 172,000 m^3 above NWL , assuming restricted outflow below top of extended detention (TED) level of 17.3 m AHD (30- 48 hours critical duration).
- Water surface area at NTWL will occupy about 53% of the area subject to inundation in the 100 year ARI flood event.
- Permanent pool = water volume of water impounded at Normal Top Water Level = 80 ML.
- The total volume of cut = 206,000 m^3 (SWS 2004).
- All cut material is assumed to be able to be used to fill abutting development land, subject to confirmation of suitable quality.
- The proposed wetland system will achieve the best practice pollutant removal targets for all parameters for the combined O'Sheas Rd and Homestead Rd DS catchments.
- Benefit to other catchment would justify some contribution towards the cost of works within the Homestead Rd DS from the O'Sheas Road DS or other MWC funding programs.
- The total drainage/recreation reserve area shown on Figures 2 and 3 is approximately 24.0 ha which infers about 4.5 ha of flood-free recreation land. This additional area could be reduced if desired to increase developable land area.
- The wetlands must include provision for all considerations detailed within the Craigie/Condina January 2005 report to ensure no ongoing water quality problems within the water body itself.

The strategy has the following major benefits:

- Flood conveyance;
- Storage and reduction of peak flows to downstream areas;
- Provision of stormwater quality treatment to at least current best practice requirements;
- Landscape, scenic, and passive recreation values;
- Habitat for aquatic flora and fauna and other aquatic ecosystem values, and
- Community, social and environmental education values.

As is current practice MWC would assume maintenance responsibility for the wetland water areas plus fringing land to the 1 year ARI flood level (which is 0.6 m above NTWL). Council would be required to maintain the balance of the reserve areas and any landscape fittings and trails (other than MWC access tracks). Facilities such as trails, boardwalks and viewing platforms can all be overlaid on the concept design but in accord with normal convention will not be managed by, nor paid for, by MWC.

It has been agreed by MWC that the proposed linear wetland/flood storage system is supported as a suitable means of resolving the significant drainage and flooding problems in the area. Therefore, in an engineering sense the drainage strategy allows rezoning of the Homestead Road Extension DSS area.

4. Development Staging Issues

4.1 Staging

The current drainage situation is unsatisfactory as it perpetuates the existence of an “island” of a number of rural-residential sized properties surrounded by conventional urban residential development. The low lying flat nature of the area limits the uses of these properties in wet seasons and invites ongoing drainage problems with stormwater generated from the upper, more highly developed areas.

With the implementation of the proposed linear wetland pondage system as proposed above, the balance of the study area outside of the drainage reserve could be developed for high quality residential housing.
All property owners will depend on the creation of a drainage reserve with appropriate flood storage, and filling outside the reserve as necessary to facilitate land development. Therefore a major issue regarding strategy feasibility is how development and wetland construction is staged.

With the “level-pool” wetland system and uniform flood level throughout, the concept was designed to allow for progressive wetland and development implementation.

Neill Craigie has stated that it is not necessary to build all of the wetland system in one go. It is entirely feasible to construct the system as a "patchwork" provided that drainage lines are not dislocated for intervals by filling.

It is also possible to modify the alignment and shape of the reserve provided that overall area remains the same.

However, any staging plan must address the following issues:

- A developed parcel of land must be able to achieve an outfall. That is the parcel of land must slope to a low point at the required surface grade and the piped drainage servicing that parcel of land must also incorporate a slope (and pipe cover) to drain the land. As the outfall level at the wetland is set (by the NTWL), these slopes may be required to be achieved via extensive filling in excess of that required for flood protection.
- No downslope development must cause increased flooding on an (undeveloped) upslope parcel of land due to filling.

Therefore, in general, the staging will work best if:

- the wetland is constructed from downstream to upstream (north to south) so that all constructed wetland cells essentially have a “wetland” outfall.

- A development stage will generally require a constructed wetland cell either adjacent to, or just downstream of its main outfall point. In this way all development will incorporate adequate pipe outfall provisions.
- Upslope developments should precede or be built in conjunction with down slope developments.

Figure 4 details a suggested possible staging plan developed by Neil Craigie. As shown the stages are generally in agreement with the principles. It is proposed to use this plan as a basis for moving forward in regard to implementing a viable staging plan for the development.

Figure 4 Possible Staging Plan, Neil Craigie

4.2 Compensation

All landowners are required to be treated equally based on the present area of their land and not on where it occurs within the present floodplain/study area (although some adjustment could be made for properties now clearly shown as being wholly or partially within the existing floodplain).

Neil Craigie has suggested (Homestead Road Drainage Area Study Report, 31 January 2005) that a formula be developed which equitably compensates landowners essentially according to the proportion of the total area each owns compared to anticipated residential land values, less the costs of implementing and maintaining the drainage strategy.

A compensation formula could be developed by the proponents of development in conjunction with MWC and/Council in consultation with the landowners and other affected parties.

It should be noted that strategy costing to date has not included reserve acquisition costs. The land acquisition costs were originally to be included in Councils DCP. Following discussion, MWC accepted acquisition provided development was viable. MWC are now suggesting that reserve acquisition should now be included in the DSS costs. MWC would like expert's opinion on land value.
MWC suggest that a better arrangement may be for the owners to donate their land to MWC as part of a development arrangement if this is possible. This would save on administrative costs and reduce risk.

Given the number of landowners, it is anticipated that the most viable scheme will be for MWC to acquire the reserve as part of the DSS and compensate affected landowners via allowance for the reserve acquisition in the DSS rate.

Whatever the case all effort should be made to ensure all landowners have some part of their land able to be developed so that they can all participate in the ongoing benefits of the development potential of the land.

5. Issues of Importance

The discussion detailed above shows that the drainage strategy, in an engineering sense, can facilitate development of the study area. However, development viability is dependent also on the economic feasibility of the proposal. Items affecting the economic viability of the strategy are discussed below.

5.1 Contribution area

Any strategy should aim to maximise the developable area given due respect to all other considerations (urban design, ecological, environmental etc).

The larger the developable area, the less each individual landowner will be required to contribute per hectare for infrastructure costs.

Charter Keck Cramer identified the following in their 2008 Development Cost Report.

- Site area = 83.52 ha
- Open Space = 22.83 ha
- Road Reserve = 6.36 ha
- Net Developable Area = 54.33 ha

These values vary slightly from the assumptions detailed in the 2004 MWC DSS plan. However, they are considered reasonable given that design changes over time will vary any assumptions made at this time slightly anyway.

5.2 Development Fill Requirement

Under the current drainage strategy, a large volume of fill will be required to raise developable land to incorporate 600mm freeboard to future floor levels and to provide adequate lot and outfall pipe grades.

Charter Keck Cramer (CKC) used a polygon model based on Stormy Water Solutions 2004 development contours and detailed survey information to estimate the following.

- Fill requirement = 2,000,000 m^3
- Wetland volume = 330,200 m^3
- Required Fill Volume (assumed by CKC) = 2,000,000 - 330,200 = 1,669,800 m^3
- CKC costed this at $11/m3 = $18, Wetland volume = 330,200 m^3 = $18,367,800

Stormy Water Solutions and Neil Craigie consider that this is an underestimate. Fill costs still occur even when you don't have to import the fill, probably at half rate. CKC seem to have apportioned "construction costs separately" , but even allowing for this a "rate" for fill sourced on site should apply.

Assuming the MWC DSS rate of $20/m^3 for imported clean fill (excluding engineering and contingencies) and $6/m^3 for filling with onsite cut, actual fill costs could be in the order of $35.5M based on the volumes detailed above.

As such, the current fill costs, as applied to the current drainage strategy, are considered low.

5.3 Scheme and Outfall Drainage Works

Charter Keck Cramer used the MWC Development Services Scheme (DSS) information to estimate the drainage scheme and outfall works cost. CKC interpreted the information provided by MWC (which was a revised figure based on the 2004 Stormy Water Solutions cost estimate) of $7,618,501 (wetlands, levee banks, pipelines and associated structures).

However, this was total project cost apportioned between O'Sheas Rd DSS, Homestead Road DSS and Homestead Road Extension DSS. Table 1 summarised the cost apportioning between schemes as currently applied by MWC. Actual cost for Homestead Road Extension DSS (as apportioned by MWC) is $5,647,607. The current MWC rate is $102,126 /ha, which implies an assumed contributing area of 55.3 ha. This is fairly consistent with the assumed developed area detailed by CKC above.

As detailed in Table 1, there has been no flood storage component apportioned to the O'Sheas Road DSS scheme. If this were to be justified, DSS cost apportioning to the Homestead Road Extension DSS may be reduced. Stormy Water Solutions and Neil Craigie consider that a flood storage contribution from O'Sheas Road SSS is justified. The 1 m^3/s inflow from O'Sheas Road DSS is a continual inflow that mounts up over the flood duration.

Table 1 Current MWC Apportioning of DSS Costs

DSS Cost	Cost as Per current DSS	Apportioning		
		O'Sheas Rd DSS	Homestead Road DSS	Homestead Road Extension DSS (i.e. Subject Site)
Water Quality Wetland Works	$2,068,669	56%	24%	20%
Flood Storage and Associated Hydraulics	$4,002,601	0%	8%	92%
Levee Augmentation and DSS Pipelines	$1,547,232	0%	0%	100%
Total DSS Cost ($M)	$7.62	$1.16	$0.82	$5.64

Given the above, the current MWC DSS drainage costs, as applied to the current drainage strategy, are probably a little bit high.

5.4 Wetland Reserve Acquisition

Council requested Charter Keck Cramer to include acquisition costs in their Development Cost Report. However, this item was not included.

The current MWC DSS development contribution rate of $102,126 /ha, may be very low given acquisition is not accounted for.

If the drainage reserve acquisition is included in the costing it could be between $7 - $12 million, depending on the reserve area required for the wetland purpose and the value of the flood prone land to be acquired.

It should be noted that the existing Homestead Road Retarding Basin and part of the existing Golf Links Road Retarding Basin site are currently owned by MWC.

The equity issue of ensuring no one landowner is adversely impacted on by wetland placement must also be addressed.

5.5 Summary of Drainage and Fill Cost Implications

As summarised in Table 2, the actual subdivision fill, DSS costs and reserve acquisition cost may be more in the order of $50M, rather than the $26M estimated by Charter Keck Cramer. Given the current estimate indicates that development viability is marginal, all effort must be made to reduce these costs if development is to proceed.

Table 2 Possible Cost Implications

Item	**Charter Keck Cramer Estimate $ M**	**Reviewed Estimate $ M**	**Comments**
Sub divisional Fill	$18.4 M	$35.5 M	Review Based on 2004 fill plan and current MWC fill costs
DSS Costs	$7.6 M	$5.6 M	Reviewed estimate may be less if more flood storage costs apportioned to O'Sheas Rd DSS or Homestead Road DSS
Reserve Acquisition	$0.0 M	$7 M	Review based on 14ha @ $500,000 per ha (excl. existing MWC owned land)
Total	$26.0	$48.1	

6. Strategy Optimisation

Given the above, the following is suggested as a starting point to be discussed by MWC, the GAA and Casey City Council to optimise the strategy with regard to cost implications, while retaining the intent of the original drainage strategy.

6.1 Development Areas and Reserve Areas

The design team should investigate various reserve configurations to optimise the developable area and ensure equitable apportioning of “developable” land amongst the existing landowners.

Council suggested the layout detailed in Figure 5 in their 2008 Development Plan. This plan does appear to address this issue to some degree. It also accounts for existing development such as the Buddhist temple. However, there may be other configurations which are more equitable.

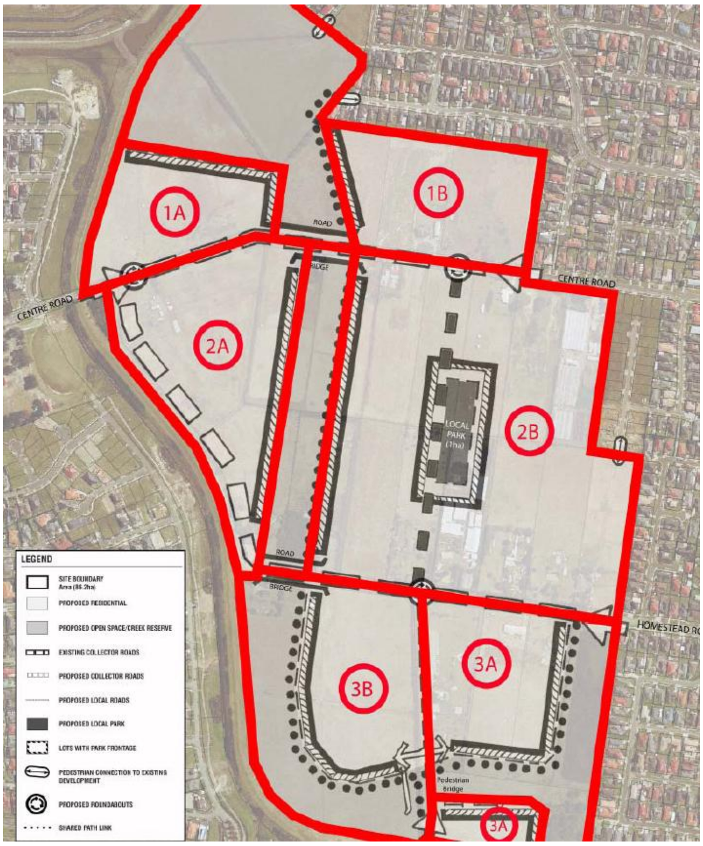

Figure 5 Council’s 2008 Development Plan – Berwick Waterways

In addition all effort should be made to clearly identify the:

- Minimum reserve area required for wetland and flood mitigation functions
- The minimum amount of area required for open space purposes
- Where the above functions can be dual purpose.

In this way, a plan detailing maximum developable area and therefore minimum development cost per hectare can be developed.

These decisions should not be made lightly and should be based on sound hydrological engineering investigations and existing and future ecological and environmental requirements. It should be noted that CKC assumed in their costings that public open space would be “satisfied in land”. They stated that if any further open space is required over and above the proposed waterway reserve then loss of yield will result. Council will be required to confirm this assumption.

Not withstanding the above, there is also scope within the current strategy to vary wetland shape in any property to best suit development layout and landscape design.

6.2 Minimise Development Fill Requirement

Obviously the fill requirement detailed in the existing strategy is forming a large proportion of the development cost.

There are many ways to possibly reduce the fill requirement of the development. These are:

1. In some cases it is possible to reduce the flood level by reducing the extended detention on the wetland from 17.4 m AHD to 17.15 m AHD (i.e. from 500 mm to 250 mm). Water quality requirements can probably still be met, as these are exceeded in the current design. This design change can allow more outflow early in the hydrograph and possible reduce storage requirements. However existing syphon outfall drain now prevents water flow through the syphon until water levels upstream of the levees exceed about 17.40 m. However, there is a new flood-gated outlet to be built. With this outlet there may be an opportunity to increase the discharge capacity in the EDD range which may be used to optimise flood storage.

2. In some cases it may be possible to reduce NTWL of the wetland to deepen pipe invert levels and therefore reduce the fill “cover” requirements over the development pipes. However, in this strategy this cannot be achieved as downstream invert controls limit NTWL to 16.9 m AHD (confirmed by MWC survey information and design plans).

3. The current MWC freeboard requirement to the 100 Year ARI flood level in the wetland reserve is 600 mm. If this freeboard requirement was reduced from 600 mm to 300 mm, the fill requirement could reduce by about 162,000 m^3 (540,000m^2 by 300 mm). At \$20/m^3 (MWC rate for importing and placing clean fill) this could save in the order of \$3.2 M. A Section 173 agreement would be required to ensure this occurs. A variation on this theme would be to maintain the same freeboard

to building floor levels but allow lesser filling overall, including allowing roads to be set at 100 year ARI flood level.

4. The fill requirements proposed by Stormy Water Solutions in 2004 assumed an outfall pipe slope of 1(vertical fall) in 250 (horizontal). Pipe slopes could be reduced to 1/600 and still meet MWC minimum pipe velocity requirements. Substantial fill reductions could occur.

5. The fill requirements proposed by Stormy Water Solutions in 2004 assumed a minimum lot slope with developable areas of 1 in 250 to 1 in 300. If allowed by Council, reduction in lot slopes could reduce fill requirements. Saw tooth longitudinal profile road designs etc could be incorporated.

6. The closer a wetland is located to a development site the less fill is required to drain that land towards the wetland. Wetland configurations should be considered which replace some of the current linear reserve area as "finger extensions of the wetland system extending into the development. Local low areas could also contain wetlands connected by balance pipes to achieve the same objective. Substantial fill reductions could occur. To achieve this outcome MWC will be required to recognise that the wetland "fingers" are still an integral part of the overall flood retention system and will be subject to MWC maintenance responsibility.

7. It is anticipated by some parties that providing additional retarding basins within the development could reduce the flood retention requirement within the wetland areas. However, due to the extensive constriction of outflow from the system by the syphon, it is anticipated that any additional retardation in the catchment would have minimal flood retention benefit. It is anticipated that this will be confirmed during the course of this investigation.

6.3 Minimise DSS Scheme and Outfall Drainage Costs

The DSS costs form a major part of the development cost. Ways to possibly reduce the DSS costs are:

1. Underground storages could be used to minimise flood retention landtake. However, these systems are extremely expensive. Required underground systems could cost in the order of $85M (at $500 per m^3 of flood storage). Hence they are not applicable to this application.

2. As with point 6 above, wetland configurations should be considered which provide fingers of the wetland system to extend into the development. These wetlands could essentially replace DSS pipes and therefore reduce the DSS costs.

3. As with Point 7 above, incorporating rainwater tanks for toilet flushing on all properties could reduce the wetland and/or flood storage requirements in the wetland area. Impact on flood

storage requirements and wetland requirements is expected to be minimal. A Section 173 agreement over the entire subdivision would be required to achieve this objective.

4. A possible way to reduce DSS costs could be to reduce the DSS pipe capacity requirement from a 5 Year ARI to (say) a 2 year ARI. The implications of this decision would need to be fully investigated. Agreement would be required from all parties.

5. All possible effort should be made to minimise reserve requirements to minimise acquisition and construction costs. A clear understanding from the project team is required to assess minimal buffer, landscape, and access path and boardwalk requirements to ensure the landscape appeal of the asset is not compromised.

6. Incorporating assets such as football ovals with (say) a 2 or 5 Year ARI protection could provide Council POS provisions while still providing the dual benefit of providing flood storage adjacent to the wetland area.

7. The present reserve flood storage volume assumes higher density residential development. If the development density varies from this assumption, reserve flood storage costs could be less than assumed. As such, a desktop exercise to assess the difference in flood storage requirements could be performed assuming different development scenarios. Clear direction from Council and the GAA is required regarding the landuse development options.

8. As detailed in Table 1, this scheme is providing flood retention and wetland benefits to the Homestead Road DSS, the O'Sheas Road DSS and the Homestead Road Extension DSS. MWC have already apportioned wetland costs between the three schemes to ensure that the Homestead Road Extension DSS is not contributing more than it needs to the reserve works. It could be argued that the same methodology should be applied to flood storage. As such, a desktop exercise excluding the 1 m^3/s input from O'Sheas Road DSS and the input from the Homestead Road DSS should be performed to assess how much of the flood storage requirement is actually due to the development of Berwick Waterways. Of course, as both O'Sheas Road DSS and Homestead Read DSS are fully developed, MWC would have to agree to fund the cost difference.

9. There is scope to increase or reduce the volume of cut within the wetland reserve (by adjusting subsurface bathymetry), so as to alter the balance of cut/fill volumes over the length of the floodplain. This should be optimised to reduce overall costs of importing fill. Any extra cut that can be obtained from the wetland reserve will reduce overall costs but it will require MWC approval to increased overall depth and storage volume in the permanent pool.

7. Suitability of Drainage Elements within the Site

7.1 Elements which are Appropriate to Site Application

Any future drainage WSUD asset should be fully integrated within the development. In addition they should:

- Consist of (as far as possible) self sustaining WSUD elements which, by definition, minimise the maintenance requirements of individual WSUD elements ,
- Be sustainable in the long term,
- Be elements which maximise ecological diversity in the development landscape (including the use of open space adjacent to developments), and
- Supplement the social and landscape amenity of any future development.

It is recommended that development of the subject site facilitate the development of a robust self sustaining drainage system consisting of healthy, diverse and integrated ecological systems. The existing DSS consists of elements which are suitable and meet these criteria. In summary they are:

- Gross pollutant traps (Simple Systems)
    - In their simplest form these are screening devices designed to capture litter and can be as simple as a vegetated barrier at a pipe outfall.
    - If primary/secondary vegetated systems are located downstream there is no need to incorporate more expensive and complicated GPT’s
    - GPT’s are a critical design element in residential subdivisions to ensure litter does not affect the landscape amenity of any downstream WSUD feature.

- Filter or buffer strips
    - A vegetated strip of land that usually runs parallel to a road for example which filters out litter and course sediments before the water enters the drainage network.
    - Simple in design and construction and adherence to the treatment train concept.

- Sediment basins
    - used to pre-treat water before it enters a wetland

- “On Line” Wetlands
    - Linear wetland systems designed to ensure subdivision outfall meets best practice as defined above

- Can significantly aid in reducing invert maintenance problems (typical in shallow drainage paths)
- Facilitate piped systems in the local development by providing a “deep” point (as defined by the wetland normal water level) for development pipe outfalls
- High social and landscape amenity role
- Can minimise bird population issues by ensuring minimal large open water pondages within the wetland areas and maximising wetland vegetated areas
- Can add significant habitat diversity to reserve areas.

7.2 Elements which are not Appropriate to Site Application

Elements which may be considered, but which may have limited applicability to this site are:

- Ponds or lakes which, due to the size of the water body proposed, may be prone to water quality problems. Vegetated wetlands minimise these risks by providing a robust ecological system below the water line. However it needs to be kept in mind that selective addition of open water zones in a linear wetland not only adds greatly to landscape appeal, it also reduces volumes of fill that would otherwise need to be imported to the site.

- Vegetated or grassed swales with in road reserves. These systems are small (typically less than 4 m wide) linear systems which run along the edge of road pavements. Systems of this type tend to contribute very little to the ecological diversity of a region when placed close to subdivisions. In areas where surface slopes are very slight, they should be used with case due to the required maintenance to ensure constant drainage slopes at all times.

- Bioretention swales, bioretention basins (rain gardens) and tree planter bioretention systems which tend to contribute very little to the ecological diversity of a region when placed close to subdivisions. These systems require relatively deep outfall systems which are not available in this area of interest. Hence these systems are not applicable within the subject site.

The elements above which can also tend to have ongoing problems with filter media blockage, vegetation management, high maintenance costs and perforated pipe blockage, particularly if there is inadequate design or construction quality control.

As the over-riding control on land area is associated with the flood storage volume, the wetland area is effectively over-sized in terms of water quality treatment outcomes. This means that addition of extra WSUD assets across the development area will not reduce flood volume and hence will not reduce land take overall for drainage purposes.

8. Recommendation

It is recommended that the Growth Areas Authority, Melbourne Water Corporation and the City of Casey and the consultant team workshop all issues identified in Sections 5 and 6 of this report.

It is anticipated that at least 3 options will be identified for further investigation. These solutions will be investigated regarding their engineering feasibility and economic benefit by Stormy Water Solutions and Neil Craigie. As detailed in this report the main issues to be addressed are to:

- Reduce fill volume as much as possible
- Reduce MWC Development Services Scheme (DSS) Costs as much as possible, and
- Reduce reserve area requirements to minimise reserve acquisition costs.

This report indicates that the actual fill and DSS costs in the order of $26 M as specified by Charter Keck Cramer may be underestimated. CKC did not allow for the cost of placing fill sourced on site and they did not allow for drainage acquisition costs. Actual drainage system and fill costs may be in the order of $50M. As such, for development of the area to be viable all effort must be made to reduce subdivisional fill and drainage infrastructure costs.

The ultimate objective is to produce a drainage strategy which can meet all the drainage requirements while facilitating cost effective development of Berwick Waterways.

9. Abbreviations, Descriptions and Definitions

The following Table lists some common abbreviations and drainage system descriptions and their definitions which are referred to in this report.

Abbreviation Descriptions	**Definition**
AHD - Australian Height Datum	Common base for all survey levels in Australia. Height in metres above mean sea level.
ARI - Average Recurrence Interval.	The average length of time in years between two floods of a given size or larger
Ephemeral Waterways	Waterways which flow for only short periods of time after rainfall events.
Bio-retention swale	A swale where the base contains a filter zone which storm water slowly seeps though to assist in stormwater pollutant removal
Bio-retention system	A swale or nodal basin where the base contains a filter zone which storm water slowly seeps though to assist in stormwater pollutant removal
Ephemeral Wetlands	Wetlands which are either rarely inundated or only inundated for a very short period of time.
DSS	Refers to a Melbourne Water Corporation Development Services Scheme
Evapotranspiration	The loss of water to the atmosphere by means of evaporation from free water surfaces (eg. wetlands) or by transpiration by plants
Groundwater	All water stored or flowing below the ground surface level
GAA	Growth Areas Authority
Groundwater Level	The level of groundwater below the surface level at a particular point of interest (usually given in AHD or relative to surface level)
Inlet Pond	See Sediment Pond
Hectare (ha)	10,000 square metres
Hec Ras	Hydraulic computer program used to calculate flood depths (usually to AHD) and extents given a flood flow
Kilometre (km)	1000 metres
m^3/s -cubic metre/second	Unit of discharge usually referring to a design flood flow along a stormwater conveyance system
CKC	Charter Keck Cramer – Authors of the “Civil Engineering Development Cost Report, Proposed Residential Development, Berwick Waterways, October 2008
Megalitre (ML) (1000 cubic metres)	1,000,000 litres = 1000 cubic metres. Often a unit of water body (eg pond) size

Abbreviation Descriptions	**Definition**
MUSIC	Hydrologic computer program used to calculate stormwater pollutant generation in a catchment and the amount of treatment which can be attributed to the WSUD elements placed in that catchment
MWC	Melbourne Water Corporation
Pond	A small artificial body of open water (eg. dam or small lake)
Retarding basin	A flood storage dam which is normally empty. May contain a lake or wetland in its base
RORB	Hydrologic computer program used to calculate the design flood flow (in m^3/s) along a stormwater conveyance system (eg waterway)
Sedimentation basin (Sediment pond)	A pond that is used to remove coarse sediments from inflowing water mainly by settlement processes.
Surface water	All water stored or flowing above the ground surface level
Swale	A WSUD element used to collect primarily course sediments and TSS. Essentially trapezoidal cross-sectional form. Often fully vegetated with indigenous species, or grassed.
Total Catchment Management	A best practice catchment management convention which recognises that waterways and catchments do not stop at site boundaries and decisions relating to surface water management should consider the catchment as a whole
TSS	Total Suspended Solids – a term for a particular stormwater pollutant parameter
TP	Total Phosphorus – a term for a particular stormwater pollutant parameter
TN	Total Nitrogen – a term for a particular stormwater pollutant parameter
Vegetated Channel	A floodway vegetated and landscaped into a naturalistic form. A complementary function to the flood conveyance task is its WSUD role (where the vegetation in the base acts as a swale).
Waterlogging	Term used to describe saturated surface soil conditions where some free surface water may also be present
WSUD - Water Sensitive Urban Design	Term used to describe the design of drainage systems used to o Convey stormwater safely o Retain stormwater pollutants o Enhance local ecology o Enhance the local landscape and social amenity of built areas
Wetland	WSUD element permanently or periodically inundated with shallow water and either permanently or periodically supports the growth of aquatic macrophytes