Stormy Water Solutions

Hydrological and Environmental Engineering

Grasslands Retarding Basin and Wetland Functional Design

Officer

8 April 2011

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1. Introduction

In October 2010 Stormy Water Solutions undertook an options analysis relating to the proposed Grassland Retarding Basin site in Officer. This analysis identified two potential design issues associated with the current DSS proposals in the area. These were that:

- The bypass channel, proposed in the Melbourne Water Corporation (MWC, Development Services Scheme (DSS), north of the railway will result in a significant un-retarded flow upstream of the railway. This flow probably results in a head water level upstream of the railway higher than the previously proposed MWC spillway crest level.

- The existing invert level of the outfall drain at the Princess Highway culvert (upstream end of the retarding basin) is 32.3 m AHD (Vic Urban detailed survey). The natural surface is about 33 m AHD. As such, there is **NO** provision to service the DSS pipeline coming in from north of Princes Highway or the DSS pipeline running along the southern boundary of the Princes Highway. The only way to service these two pipelines (under current DSS proposals) is by filling to ensure adequate pipeline cover and lot slope provisions. Very roughly, south of the highway, this would require an average of about 700 mm fill (2 m max) over about 43 ha resulting in about 300,000 m^3 fill. At $28 per m^3 for clay fill (including engineering and contingencies); this could result in about $8.5M of fill requirement just for the area south of the highway. This has significant implications in regard to the development potential of Officer.

Stormy Water Solutions proposed an option to address the northern pipe outfall invert level issue. A wetland system was proposed in the retarding basin site. The uniform normal water level of the wetland ensures could ensure about a 1.65 metre depth from natural surface to the pipe invert level immediately downstream of the Princes Highway. This is an outfall much more in line with current minimum DSS requirements. This options results in only minor lot shaping and filling required south of Princes Highway.

Following a meeting between DSE, MWC, Cardinia Shire Council and Stormy Water Solutions in late 2010 it was agreed by all parties that the wetland option should be developed further, given due consideration of the existing site grassland issues. In March 2011 Stormy Water Solutions produced a draft functional design report which specifically:

- Details a catchment strategy required to ensure cost effective development of areas west and north of the Grassland Retarding Basin,
- Details the concept design of incoming pipelines to the retarding basin site, and
- Details the functional design requirements of the Grasslands Retarding Basin and Wetland system.

This report updates this earlier work. The April 2011 update accounts for:

- Retarding basin outlet modifications aimed at optimising the flood storage characteristics of the site, and
- Road alignment changes required as part of the current Council PSP process, especially the requirement for a road traversing the retarding basin site.

The technical analysis, RORB modelling etc detailed in this April 2011 report supersedes the information contained in the March 2011 functional design report.

2. Design Objectives and Requirements

2.1 Environmental Protection

The functional design in this report aims to ensure that existing ecological and environmental attributes are retained and enhanced. In particular the impact on the existing grassland areas must be minimised during construction and the ongoing operation of the site.

This objective has been achieved by clear delineation of existing grassland areas within the retarding basin site. In general, the wetland, sediment pond and path placement has been sited outside grassland delineation lines.

In addition, the hydraulic analysis has shown that plains grassy wetland areas should still receive overflows from the main drainage line (i.e. wetland spillage) in events of less magnitude than about the 3 month ARI event. As such, regular wetting of this area is expected, as currently occurs (Section 5).

It is anticipated that the wetland proposals will significantly add the ecological diversity within the site by providing permanent wet areas (marsh and open water) and by increasing vegetation (overstory and understory) within the site.

All offsets will be required to be agreed and finalised between MWC, Council and the DSE. However, primarily these offsets relate to PSP road placement, and not the construction of the wetland system.

2.2 Flood Storage Requirements

MWC has confirmed that the design intent of the retarding basin is to limit the 100 year design flow at the railway to below the existing culvert railway capacity. That is, the DSS strategy is to ensure no railway culvert upgrade is required.

2.3 Internal Hydraulic Drainage Design Criteria

The design of the proposed retarding basin has been influenced by the requirements of the external catchments, particularly the requirement to achieve pipe outfalls for adjacent developed areas.

It should be noted that the existing outfall though the retarding basin site is relatively shallow (0.7 m deep at Princes Highway). As such, there are issues in obtaining a deep enough outfall to facilitate pipe outfall from upstream developed areas. If the existing drain invert level though the Grasslands Retarding Basin site is retained, significant fill will be required on the adjacent development to achieve pipe cover and lot slope requirements (1 in 300 lot slope assumed).

As such, the retarding basin design must show how the surrounding land can be drained and serviced to meet current DSS outfall requirements and minimise fill required for pipe cover requirements. This requires consideration of pipe invert levels, pipe sizes, outfall wetland normal water level (NWL), fill (cover) requirements over all pipes and a 1/300 minimum lot slope to probable individual lot outfall points.

Appropriate catchment and pipe drainage alignment consideration is required during the design process of adjacent and upstream development areas to ensure this occurs. This issue is addressed in Section 3 below.

In addition the design must accommodate current Council and GAA road proposals adjacent to the site, although these are subject to change.

2.4 Implication of the Proposed Officer PSP Process

The April 2011 functional design accounts for the possible placement of road systems around and through the retarding basin site as proposed in the current Officer PSP proposals.

2.5 Possible Site Scale Stormwater Management Initiatives

The proposed WSUD initiatives detailed within this report relate only to proposed MWC DSS assets.

As detailed in Section 8, current best practice in regard to stormwater pollutant treatment cannot be met with these DSS proposals alone (including the Grasslands wetland proposal).

Therefore, application of local and site scale initiatives such as raingardens, streetscape swales, on site stormwater harvesting etc. would help to supplement the current proposed DSS initiatives.

3. Proposed Catchment Management Strategy

3.1 Catchment Delineation

The issue of matching a relatively high existing outfall invert level has been overcome by incorporating "on line" wetland system in the design. This wetland can match the existing railway outfall invert level at its downstream end while, through the use of a constant normal water level, provide an outfall point in the order of 1.65 metres below the existing invert level at the upstream end (i.e. at Princes Highway).

Drainage of the surrounding development can be achieved by directing development piped systems to the upstream end of the wetland system through appropriate catchment and pipe drainage consideration during the design process of the development. The catchment delineation shown in Figure 1 is aimed at informing the future system planners and designers on the approximate catchment delineation required to meet the above objective.

Pipeline 1 services the existing development east of Brunt Road. This catchment is already serviced by a retarding basin and wetland system. As such, the proposed 1050 mm outfall pipe is proposed to run along the proposed path system to be located directly north of the railway to the railway outfall point. In minimising additional catchment input downstream of Brunt Road, the pipe size has been able to be retained at 1050 mm dia. A pipe of this diameter can convey the Brunt Road retarding basin outflow to the existing railway culvert outfall without deepening the existing railway culvert. In addition, fill over the pipeline can be minimised.

Pipelines 2 and 3 are proposed service un-developed land located west of the Grassland Retarding Basin site. The catchment delineation accounts for:

- Aiming the pipelines to the upstream end of the wetland system where pipe invert levels can be significantly lower than if the current drain was retained,
- Optimising catchment sizes to minimise pipe sizes (to reduce fill requirements), and
- Delineating the catchments to optimise primary treatment in separate sediment ponds to be located within the Grasslands Retarding Basin site,

The catchment configuration detailed (Figure 1) is preliminary only and is shown to convey the intent of the design. Of course, changes to actual catchment and assumed drainage lines will change during the detailed design process. However, in general the final design should convey the design intent of minimising pipe sizes and minimising development fill requirements. Pipe sizes are detailed in Section 3.3 below.

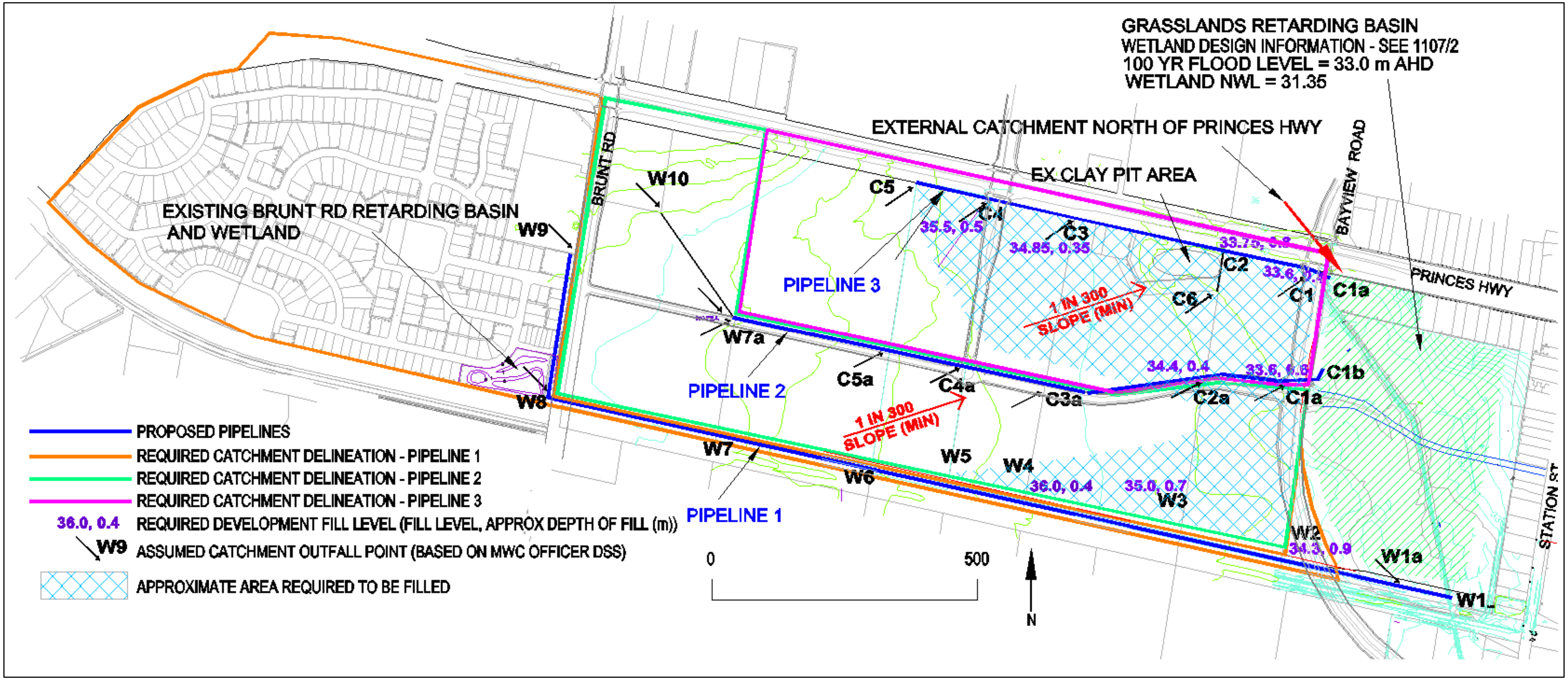

Figure 1 **Proposed Contributing Catchment Delineation**

Note: Modified for report. Refer Stormy Water Solutions (SWS) Drawing 1107/1 for full detail.

3.2 Grassland Retarding Basin and Wetland Proposals

The design of the Grasslands Retarding Basin has been constrained by the delineation of grassland areas requiring protection. It was assumed that this constraint would result in no drainage works being allowed in the site. If this was the case, the existing drain outfall invert levels would severely restrict the develop potential of adjacent and upstream land (as discussed above).

To solve the drain invert level issue an on line linear wetland, placed outside delineated grassland areas, is proposed.

This wetland:

- Results in a 1.65 m deep invert level at the upstream pipe outfall locations (Pipelines 2 and 3) and therefore solves the drain outfall issues,
- Increases the flood storage within the site,
- Should significantly add to the ecological and environmental diversity of the site, and
- Should add significantly to the social and landscape benefits of the site in the future.

Figure 2 shows the functional design of this element (SWS Drawing 1107/2). Figures 3 and 4 detail typical wetland cross sections (1107/5) and the proposed outlet configuration (1107/4).

It should be noted that, apart from grassland impact, the major constraint of design is ensuring free outfall to the railway culvert invert. As such, future design of the southern landscape path (including any required water sewer and other services) will need to account for the large 100 Year outlet box culvert proposed under the road (i.e. retarding basin outlet works). Culvert levels cannot change. As such, any required services will probably need to be placed below the proposed culvert system.

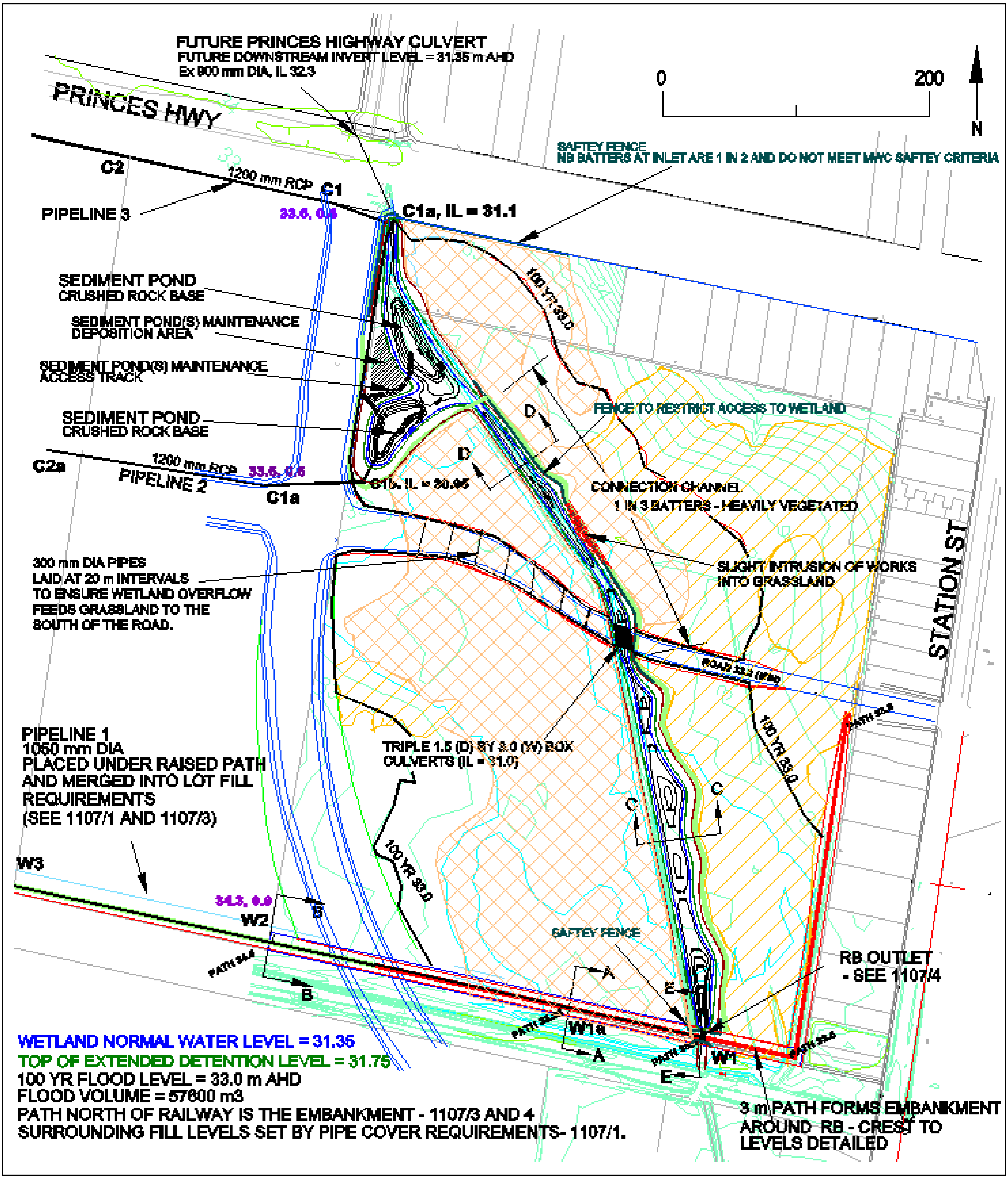

Figure 2 **Proposed Grassland Retarding Basin Functional Design**

Note: Modified for report. Refer Stormy Water Solutions (SWS) Drawing 1107/2 for full detail.

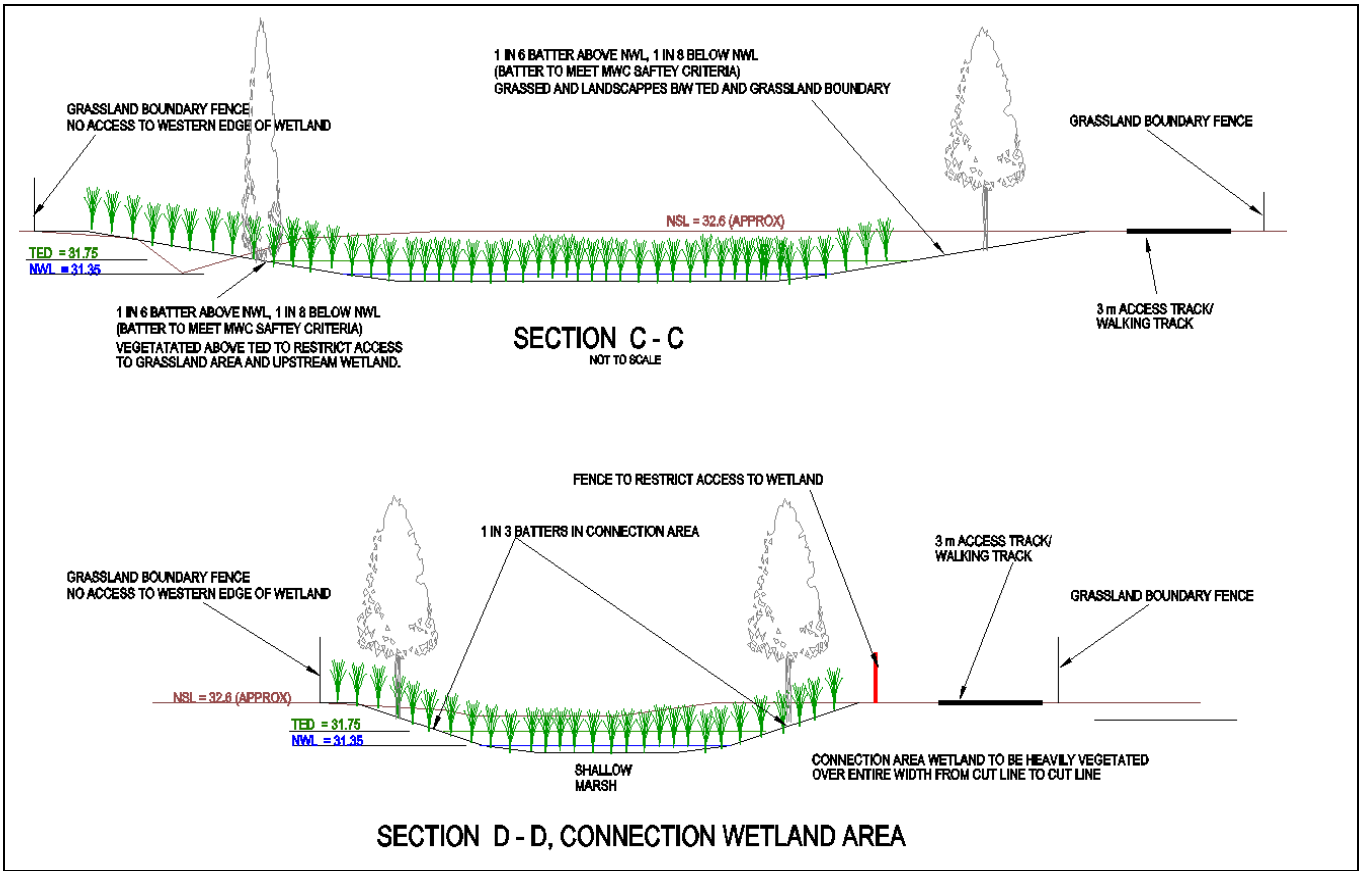

Figure 3 **Wetland Cross Sections**

Note: Modified for report. Refer Stormy Water Solutions (SWS) Drawing 1107/5 for full detail.

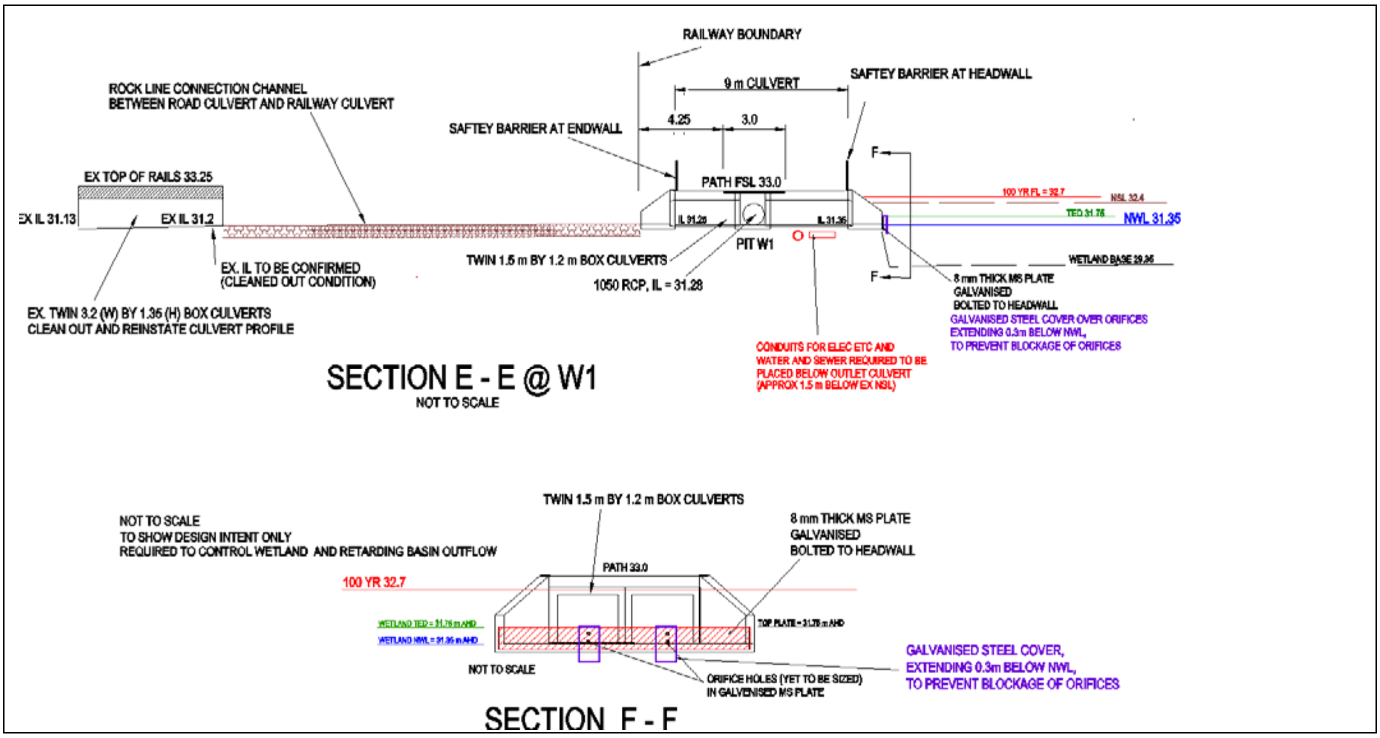

Figure 4 **Wetland Outlet Requirements**

Note: Modified for report. Refer Stormy Water Solutions (SWS) Drawing 1107/4 for full detail.

3.3 Incoming Pipeline Requirements

The concept design of the pipelines described above is detailed below. It should be noted that the invert levels, obvert levels and alignments have been used to set the preliminary fill requirements detailed in Figure 1 (Drawing 1107/1).

The fill requirements assume at least 600 mm cover to all pipelines. This is slightly less than the current MWC requirement of 750 mm and will need to be agreed to by MWC and Council.

The pipelines below should be viewed as “functional” designs. It is very important that the design intent of minimising pipe sizes and contributing catchments is utilised to minimise development fill requirements.

Table 1 **Pipeline 1, Southern Line, Functional Design**

Pipe Ref.	Upstream Area (A)	Cumulative Upstream Area SA	5 Year ARI Runoff Coefficient C_5	ARI (y)	Effective Area A_e	Cumulative Effective Area SA_e	Time of Concentration t_c	Rainfall Intensity I_y	Design Flow Q_y	Length L	Obvert Elev u/s	Obvert Elev d/s	Slope S	Pipe Diameter	Full Flow Q_{full}	Full Velocity V_{full}	Time in Pipe t_{pipe}	Natural Surface (approx)	Cover (approx to NSL)	Fill Required	Approx fill Level over pipe	Approx fill Level - Adj Subdivision	
	ha	ha		year	ha	ha	min	mm/hr	m^3/s	m	m	m	1 in ...	mm	m^3/s	m/s	min	m AHD	m	m	m AHD	m AHD	
					-			-	-				-		-		-						
W9 - W8	3.65	3.65	0.60	5	2.19	2.19	12.00	55.88	**0.34**	265	40.00	39.55	589	675	0.35	1.0	4.56	41	1.00	0.00	N/A	N/A	Constructed
W8 - W7	47.15	50.8	0.45	5	21.22	nservative 5 year RB outfl			**1.20**	325	39.55	38.05	217	1050	1.86	2.1	2.53	40.9	1.35	0.00	N/A	N/A	Constructed
W7 - W6	0.80	51.6	0.20	5	0.16	0.16	120.00	15.03	**1.21**	295	38.05	36.00	144	1050	2.28	2.6	1.87	39.15	1.10	0.00	N/A	N/A	2 HR CRITICAL DURA
W6 - W5	0.80	52.4	0.20	5	0.16	0.32	121.87	14.90	**1.21**	145	36.00	35.50	290	1050	1.60	1.9	1.30	37.05	1.05	0.00	N/A	N/A	
W5 - W4	0.40	52.8	0.20	5	0.08	0.40	123.18	14.80	**1.22**	145	35.50	35.05	322	1050	1.52	1.8	1.38	36.3	0.80	0.00	N/A	N/A	All calcs take int
W4 - W3	0.40	53.2	0.20	5	0.08	0.48	124.55	14.71	**1.22**	300	35.05	34.05	300	1050	1.58	1.8	2.75	35.6	0.55	0.05	35.65	35.90	lot densities - P
W3 - W2	0.80	54	0.20	5	0.16	0.64	127.30	14.52	**1.23**	195	34.05	33.41	305	1050	1.56	1.8	1.80	34.4	0.35	0.25	34.65	34.90	
W2 - W1	0.50	54.5	0.20	5	0.10	0.74	129.10	14.40	**1.23**	230	33.41	32.64	300	1050	1.58	1.8	2.11	33.4	-0.01	0.61	34.01	34.26	
W1a - W1	1.1	55.6	0.50	5	0.55	1.29	131.20	14.26	**1.25**	100	32.64	32.33	325	1050	1.51	1.7	0.95	32.4	-0.24	0.84	33.30	N/A	
		checked OK			-			-	-				-		-		-	32.4	0.07	0.53	32.93	N/A	Reqd. IL = 31.28

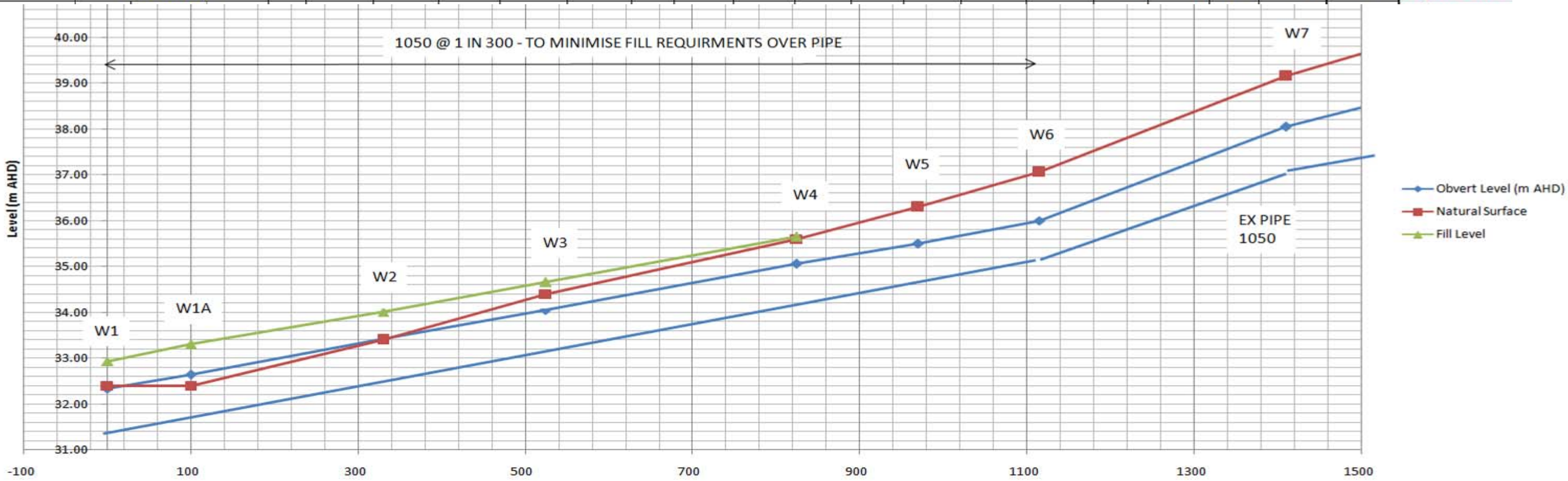

Figure 5 **Pipeline 1, Southern Line, Functional Design, Fill at W1a set by flood level in RB.**

Table 2 **Pipeline 2, Centre Line, Functional Design**

Pipe Ref.	Upstream Area (A)	Cumulative Upstream Area SA	5 Year ARI Runoff Coefficient C_5	ARI (y)	Effective Area A_e	Cumulative Effective Area SA_e	Time of Concentration t_c	Rainfall Intensity I_y	Design Flow Q_y	Length L	Obvert Elev u/s	Obvert Elev d/s	Slope S	Pipe Diameter	Full Flow Q_{full}	Full Velocity V_{full}	Time in Pipe t_{pipe}	Natural Surface (approx)	Cover (approx to NSL)	Fill Required	Approx fill Level over pipe
	ha	ha		year	ha	ha	min	mm/hr	m^3/s	m	m	m	1 in ...	mm	m^3/s	m/s	min	m AHD	m	m	m AHD
					-			-	-				-		-		-				
W10 - W7a	2.90	2.90	0.55	5	1.60	1.60	10.00	61.00	**0.27**	235	38.90	37.55	174	525	0.33	1.5	2.60	41	2.10	0.00	N/A
W7a - C5a	15.00	17.90	0.40	5	6.00	7.60	12.60	54.55	**1.15**	350	37.55	35.80	200	900	1.28	2.0	2.90	39	1.45	0.00	N/A
C5a - C4a	6.50	24.40	0.35	5	2.28	9.87	15.50	49.07	**1.35**	140	35.80	35.10	200	975	1.58	2.1	1.10	37.2	1.40	0.00	N/A
C4a - C3a	3.40	27.80	0.50	5	1.70	11.57	16.60	47.35	**1.52**	160	35.10	34.30	200	1050	1.93	2.2	1.20	36	0.90	0.00	N/A
C3a - C2a	3.40	31.20	0.50	5	1.70	13.27	17.80	45.62	**1.68**	300	34.30	33.10	250	1125	2.08	2.1	2.39	35.3	1.00	0.00	N/A
C2a - C1a	7.20	38.40	0.55	5	3.96	17.23	20.19	42.61	**2.04**	160	33.10	32.50	267	1200	2.39	2.1	1.26	34	0.90	0.00	N/A
C1b - C1b	6.0	44.40	0.60	5	3.60	20.83	21.45	41.20	**2.38**	85	32.50	32.15	243	1200	2.50	2.2	0.64	32.8	0.30	0.30	33.60
		checked OK			-			-	-				-		-		-	32.6	0.45	0.15	32.75

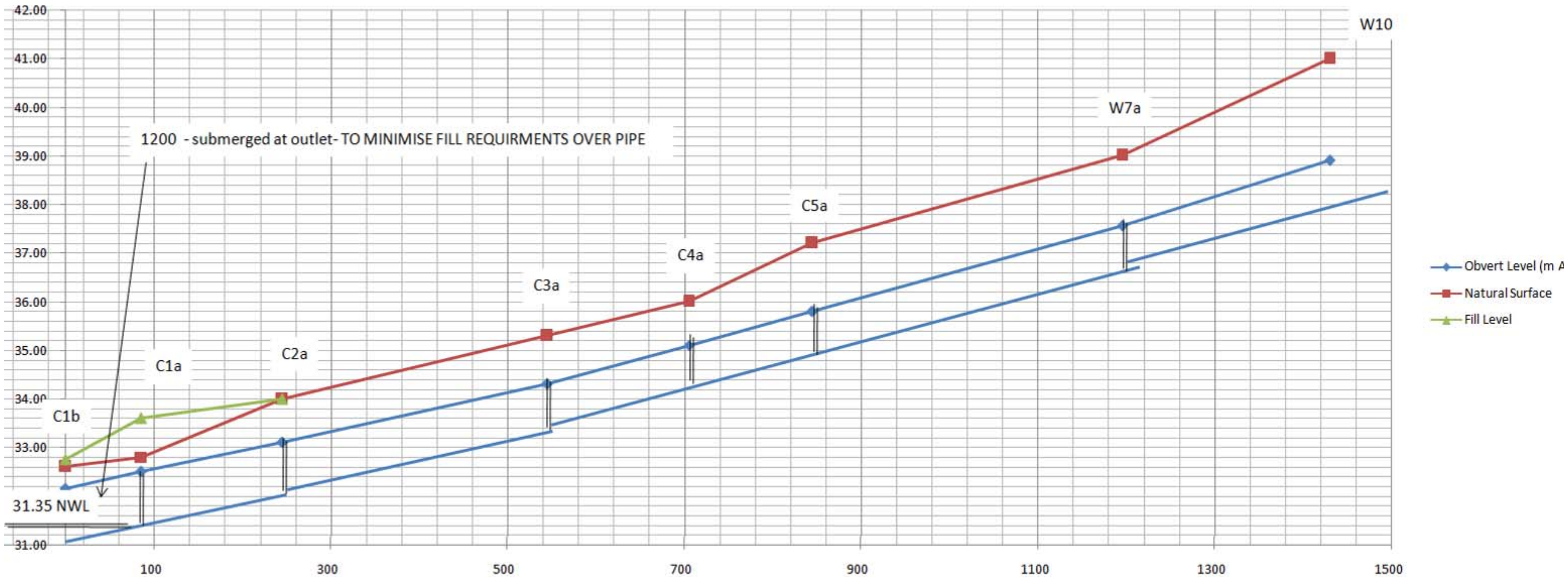

Figure 6 **Pipeline 2, Centre Line, Functional Design, Note : Fill at C1a set by flood level in RB.**

Table 3 **Pipeline 3, Northern Line, Functional Design**

Pipe Ref.	Upstream Area (A)	Cumulative Upstream Area SA	5 Year ARI Runoff Coefficient C_5	ARI (y)	Effective Area A_e	Cumulative Effective Area SA_e	Time of Concentration t_c	Rainfall Intensity I_y	Design Flow Q_y	Length L	Obvert Elev u/s	Obvert Elev d/s	Slope S	Pipe Diameter	Full Flow Q_{full}	Full Velocity V_{full}	Time in Pipe t_{pipe}	Natural Surface (approx)	Cover (approx to NSL)	Fill Required	Approx fill Level over pipe
	ha	ha		year	ha	ha	min	mm/hr	m^3/s	m	m	m	1 in ...	mm	m^3/s	m/s	min	m AHD	m	m	m AHD
					-			-	-				-		-		-				
C5 - C4	10.50	10.50	0.45	5	4.73	4.73	12.00	55.88	**0.73**	140	35.46	34.90	250	900	1.14	1.8	1.30	36.4	0.94	0.00	N/A
C4 - C3	5.30	15.80	0.50	5	2.65	7.38	13.30	53.11	**1.09**	165	34.90	34.24	250	975	1.42	1.9	1.45	35	0.10	0.50	35.50
C3 - C2	5.60	21.40	0.50	5	2.80	10.18	14.75	50.37	**1.42**	280	34.24	33.12	250	1200	2.47	2.2	2.14	34.5	0.26	0.34	34.84
C2 - C1	8.50	29.90	0.50	5	4.25	14.43	16.89	46.92	**1.88**	160	33.12	32.48	250	1200	2.47	2.2	1.22	33	-0.12	0.72	33.72
C1 - C1a	4.00	33.90	0.60	5	2.40	16.83	18.11	45.20	**2.11**	45	32.48	32.30	250	1200	2.47	2.2	0.34	32.8	0.32	0.28	33.60
		checked OK			-			-	-				-		-		-	32.8			
					-			-	-				-	All calcs take into account 2011 PSP lot densities			-	**Reqd. IL = 31.1 (partly submerged)**			
					-			-	-				-				-				

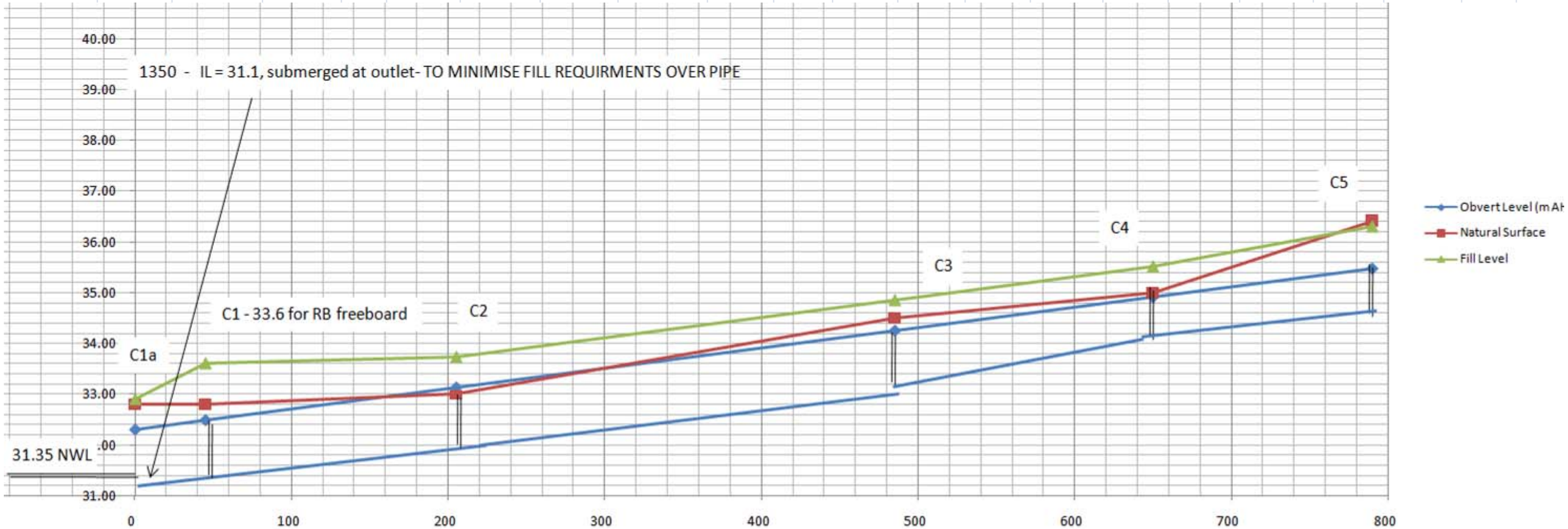

Figure 7 **Pipeline 3, Northern Line, Functional Design, Fill at C1 set by flood level in RB**

3.4 Road and Landscape Path Proposals

A crucial aspect of ensuring the proposed drainage strategy in this area is the formation of surrounding final finished surface levels. This is especially important in regard to the landscape path proposed along the southern boundary of the Grasslands Retarding Basin. Figure 8 (Drawing 1107/3) shows a concept design of this path. The objectives of the design is to meet all the future PSP road requirements and facilitate at least 600 mm fill over Pipeline 1. In addition the path will form the crest of the retarding basin embankment. It should be noted that the catchment delineation has resulted in Pipeline 1 being a 1050 mm dia RCP. No additional catchment (apart from the path itself) can be accommodated downstream of the existing Brunt Road Retarding Basin site.

In addition, road levels to some extent also set the development fill requirements immediately adjacent to the road.

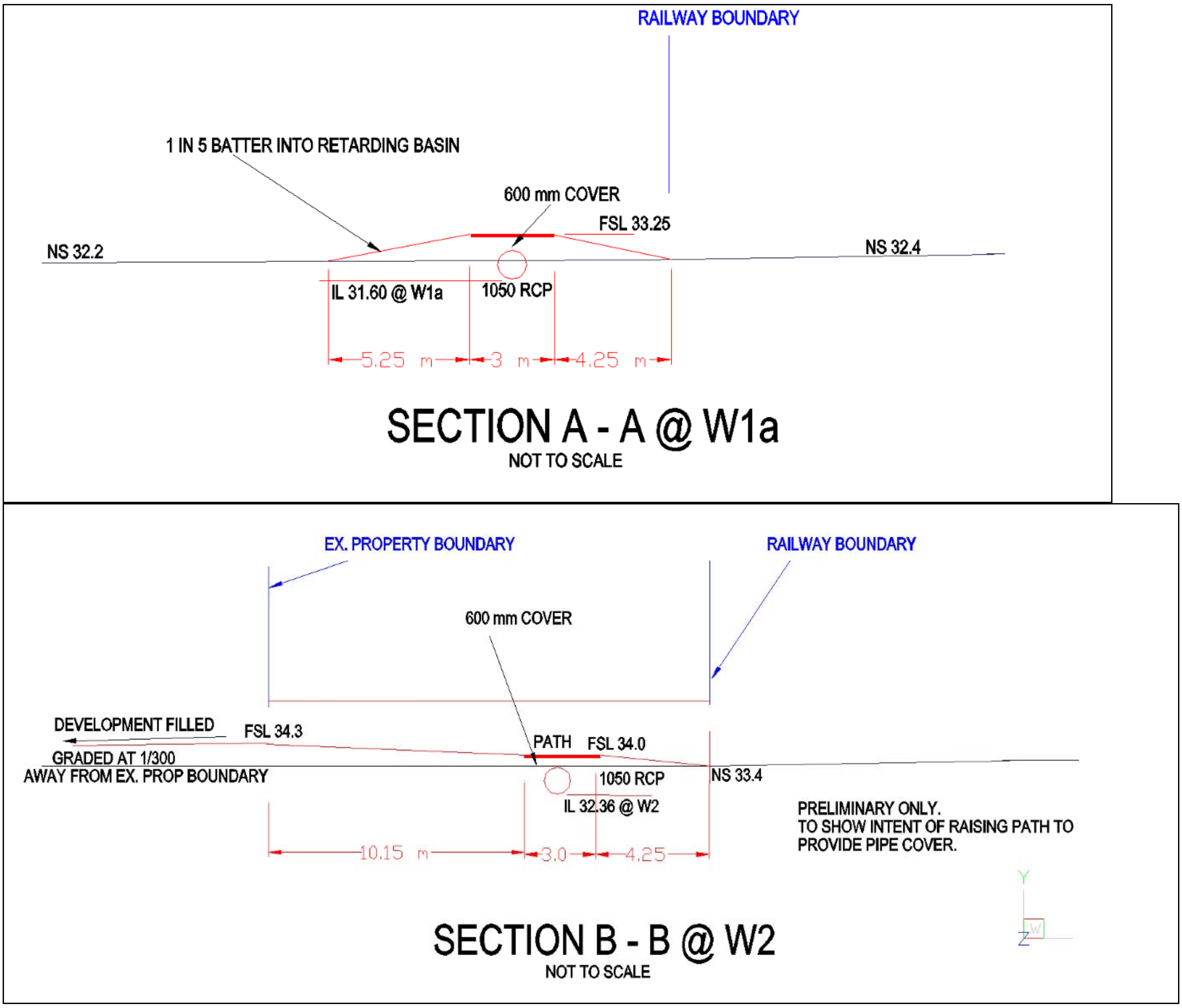

Figure 8 **Road Over Pipeline 1, Proposed Cross Sections**
Note: Modified for report. Refer Stormy Water Solutions (SWS) Drawing 1107/3 for full detail.

4. Hydrological Modelling

A hydrologic analysis using the RORB model was completed to ensure the design intent of the Grasslands Retarding Basin is met. Essentially the objectives are:

- To ensure the 100 Year ARI flow at the railway is less than the current railway culvert capacity (as confirmed by MWC in late 2010), and
- To ensure the surrounding developments (existing and future) are above the 100 Year ARI flood level in the basin.

The existing culvert railway capacity is estimated at 20 m^3/s when the headwater level is to the railway embankment level (33 m AHD), and 13 m^3/s when the headwater level is 300 mm below the railway level (32.7 m AHD). As such, it is assumed that the required 100 Year ARI outlet flow at the railway should be less than 13 m^3/s to meet MWC flow requirements.

4.1 Retarding Basin Outlet and Storage Details

The elevation/storage relationship of the Grasslands Retarding Basin was determined given the functional design detailed in Figure 2.

The operation of the retarding basin outlet detailed in Figure 4 is quite complex. Outflow from the basin outlet culvert may be affected from backwater from the railway culvert, especially in extreme events (Q > 10 m^3/s). As such, outflow relationships for both the railway culvert and retarding basin outlet were developed as detailed in Figure 9 below.

The resulting Stage /Storage/Discharge relationship for the retarding basin is detailed in Table 4 below.

Table 4 Adopted Stage/Storage/Discharge Relationship

Level (m)	Storage (m^3)	Outflow (m^3/s)	
31.35	0.0	0.0	Extended detention range
31.75	4520.0	0.05	Extended detention range
31.80	5197.5	0.9	
32.00	8167.5	1.4	
32.40	14907.5	2.5	
32.60	18817.5	3.5	
32.70	24542.5	6.0	
32.80	34797.5	7.0	
33.00	58897.5	9.2	

Retarding Basin Outlet – Twin 1500 by 1200 box culverts

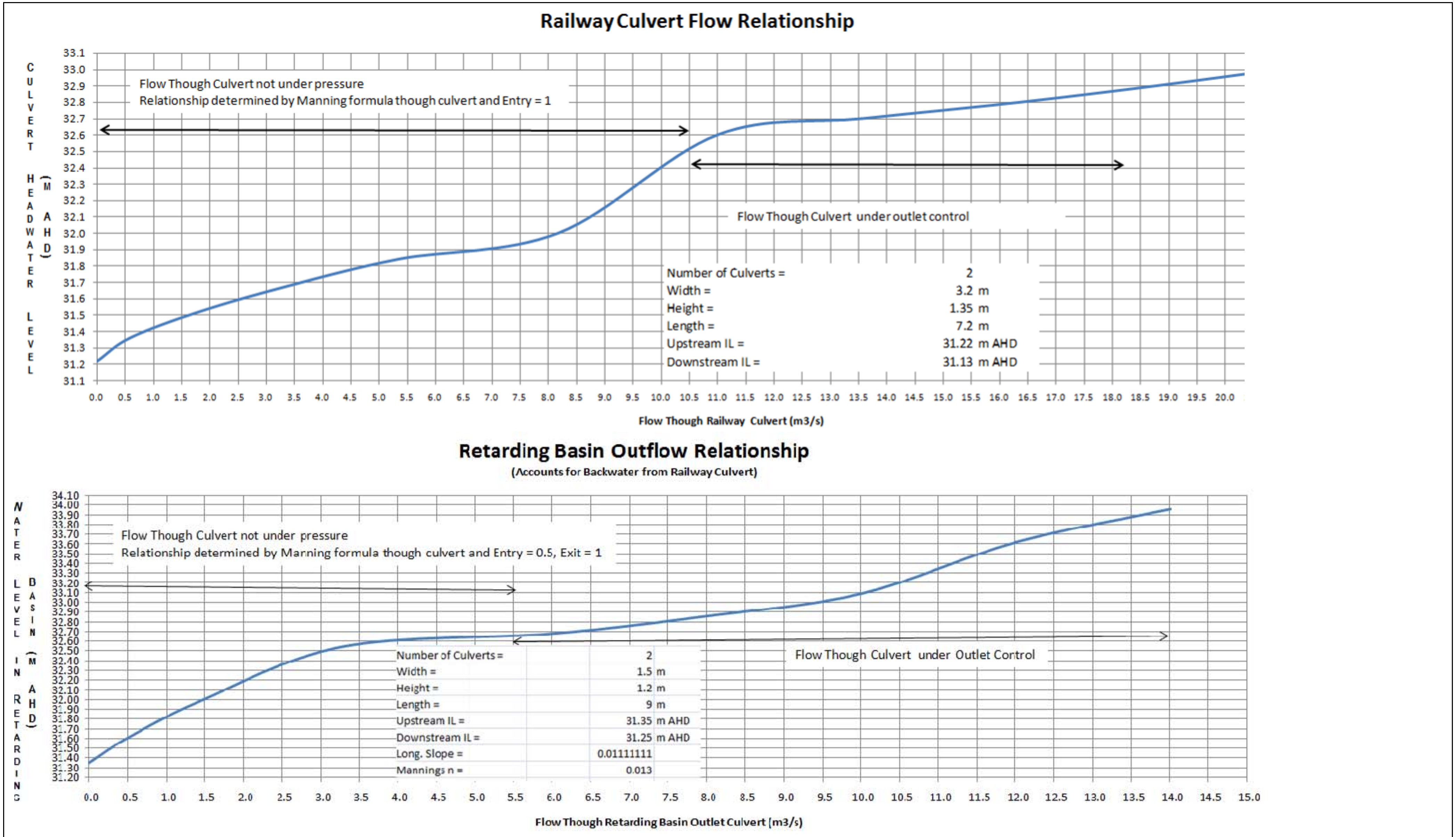

Figure 9 Adopted Railway Culvert and Retarding Basin Outlet flow Relationships

4.2 RORB Model Parameters

The intensity/frequency/duration data relevant to Pakenham, as determined by Volumes 1 and 2 of Australian Rainfall and Runoff 1987, have been used for the analysis.

RORB is based on the following equation relating catchment storage (S) and expected discharge (Q) within a stormwater system:

$$\mathbf{S = kQ^m \text{ where } k= K_c \times K_r}$$

The value of K_r is directly related to reach length, with longer reaches giving more storage effect and lower design flows.

The values K_c and m are parameters that can be obtained by calibration of the model using corresponding sets of data on rainfall for selected historical flows. If historical flows are unknown, values can be estimated from regional analysis or by values suggested by Australian Rainfall & Runoff (AR&R). In this case flow gauging information was not available. However a regional parameter set has been developed by Melbourne Water for the South East and Westernport Catchments of Melbourne. This relationship was adopted and is detailed below.

- $K_c = 1.53A^{0.55} = 3.1$
- m = 0.8
- Initial loss = 10 mm
- Pervious area runoff coefficients (C_{perv})

	100 year ARI C_{perv}	= 0.6
	5 year ARI C_{perv}	= 0.25
	1 year ARI C_{perv}	= 0.2

4.3 RORB Model Description

Tables 5 and 6 detail the RORB Model. Fraction imperviousness values are based on current development scenarios for the contributing attachments. Figure 10 shows the RORB catchment model. As detailed, the model accounts for the catchment delineation detailed in Figure 1.

Table 5 Catchment Definition

	Area (km^2)	Fraction Impervious
A	0.254	0.24
B	0.402	0.5
C	0.305	0.5
D	0.223	0.45
E	0.394	0.5
F	0.326	0.5
G	0.223	0.5
H	0.39	0.6
I	0.43	0.5
J	0.167	0
K	0.244	0.45
L	0.221	0.45
TOTAL	**3.58**	

Table 6 Reach Definition

Reach Information	Length (km)	Slope %	Type
1	0.603	7.5	Excavated Unlinec
2	0.586	4.1	Excavated Unlinec
3	0.241	8.3	Piped
4	0.66	6.5	Excavated Unlinec
5	0.7	2.7	Piped
6	1.2	2.5	Excavated Unlinec
7	0.3	1.6	Piped
8	0.38	5	Excavated Unlinec
9	0.6	0.3	Piped
10	0.8	0.3	Piped
11	0.295	0.3	Excavated Unlinec
12	0.284		Natural
13	0.5	0.3	Excavated unlined
14	1.9	0.3	Piped

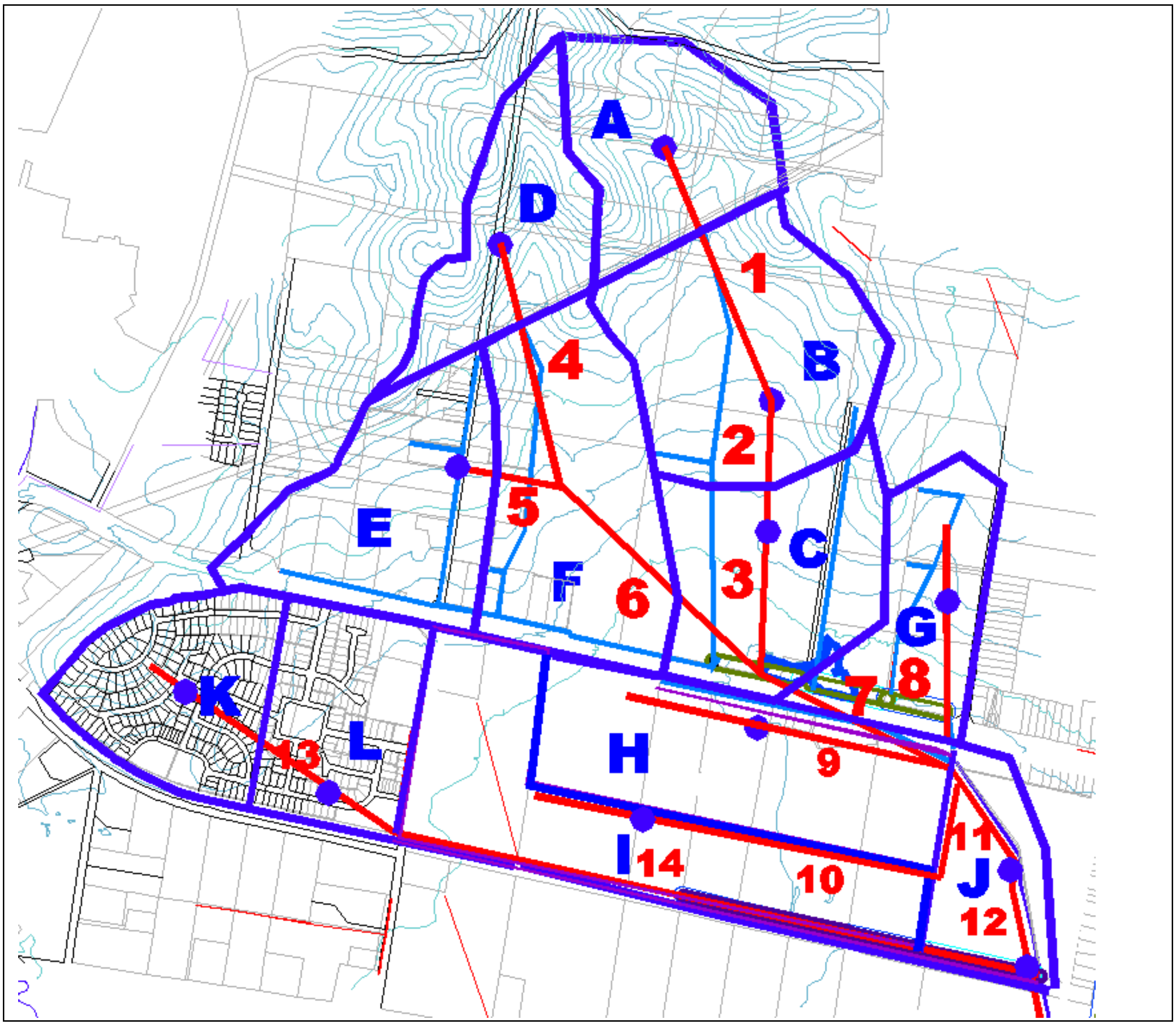

Figure 10 **RORB Catchment Model**

4.4 Models of Other Catchment Retarding Basins

Of note is that Catchments K and L bypass the retarding basin site. A rough model of the existing Brunt Road retarding basin (based on the outlet pipe design plans, aerial photo information and a site visit) has been included into the model to account for the retardation of flows from these two sub areas.

A retarding basin is also proposed over the Clay Pits (kiln area) north of the Princes Highway (intersection of Reaches 3 and 6). The proposed stage/storage/discharge relationship as provided by MWC in 2010 has been used to model the possible future impact of this system. As such, inflows into the retarding basin may change slightly given the development of a concept design for this site.

4.5 Model Verification

The model described above results in a 100 year design flow estimate of 23.1 m^3/s into the Grasslands Retarding Basin. ***This flow assumes no retarding basins north of the Highway and should not be used for design purposes***. It is required to check estimated flows against other flow calculation methods to ensure the RORB model developed is valid for its application. To achieve this check, the above design flow has been compared against other flow computational methods.

Thos “check” flow was compared to:

- flows estimated by the Rational Method, and
- Flows obtained from the Flood Regression Curves for Victoria produced by the Department of Conservation and Natural Resources in 1994.

The Rational Method requires an estimation of catchment time of concentration. This has been estimated at 1 hour at the Princes Highway. Utilising Pakenham design rainfall intensities and a 100 year ARI runoff coefficient of 0.6, the 100 Year ARI design inflow to the retarding basin flow (using the rational method) is estimated at 22 m^3/s.

An additional check has been undertaken using the Flood Regression Curves for Victoria produced by the Department of Conservation and Natural Resources. This relationship is $Q = 10.29 \times A^{0.71}$, where Q is the 100 year design flow (m^3/s) and A is the catchment area in km^2. This method indicates the 100 Year design retarding basin in flow in the order of 23 m^3/s.

The 100 year ARI flow comparisons between the RORB model, the rational method and the DNRE curves are considered quite close. On the basis of the above, the RORB model developed is considered suitable for obtaining existing and future design flows in the Grasslands Retarding Basin catchment.

4.6 RORB Results

Table 7 details the RORB results.

Table 7 RORB Results – Proposed Grasslands Retarding Basin

Location	100 Year ARI	5 Year ARI	1 Year ARI	6 mth ARI *	3 mth ARI*
Officer Road Drain West at Princes Highway (m^3/s) - Allows for Future "Clay Pit" Retarding Basin	12.9	4.1	2.4	1.6	1.0
Grassland Retarding Basin					
Total Inflow(m^3/s)	19.6	6.6	3.9	2.6	1.6
Total Outflow (m^3/s)	9.1	4.7	2.35		
Flood Storage (m^3)	58000	21,500	14,000		
100 Year Water Level (m AHD)	33	32.65	32.35		
Total Flow at Railway (m^3/s)	10.8	5.4	2.7		
	(9 hour CD)	(9 hour CD)	(9 hour CD)		
** MWC recommendation that the 3 month ARI flow may be in the order of 40% of the 1 Year ARI flow and 6 month ARI 66% 1 year ARI flow*					

As discussed above, the required 100 Year ARI outlet flow at the railway should be less than 13 m^3/s to meet MWC flow requirements. As detailed, the proposed retarding basin design can result in a 100 Year ARI below this value (10.8 m^3/s).

The existing subdivision to the east of the retarding basin will be protected from flooding upstream of the railway extension of the retarding basin embankment. The crest of the embankment on the eastern edge of the site is set at 33.6 m AHD.

The subdivision east of the site must incorporate finished surface levels of at least 33.6 m AHD to ensure this level of protection is maintained.

5. Grassland Impact Assessment

The RORB model was modified to represent existing conditions (natural reaches, rural F_{imp} and current outlet and storage characteristics in the Grassland site). This analysis indicated that the existing 100 Year ARI flow at the railway is 9.5 m^3/s. The existing flood levels are estimated at 32.7 m AHD, 32.25 m AHD and 31.95 m AHD respectively in the 100, 5 and 1 Year ARI events.

In terms of flood storage "pondage" the RORB analysis above indicates that, for the more frequent events (up to about the 5 Year ARI event), water ponds just within the existing drain, without ponding over an extensive area within the retarding basin site. That is, in frequent events, "ponding" water does not extend outside the existing drain banks (bank height approx 32.4 – 32.6 m AHD).

The occurrence of Plains Grassy Wetland in the south western portion of the site suggests that this area does in fact get wet relatively frequently. In frequent events the RORB modelling (existing) suggests that water does not "pond" readily in the site due to an outfall constriction, Rather, the existing drain capacity is limited. When the capacity of the existing drain is met, surface water cascades into the Plains Grassy Wetland area.

The proposed design aims to replicate this hydrological regime by limiting the capacity of the connection channel which connects the upstream and downstream ends of the wetland. The reduced size of this section wetland, combined with very dense wetland vegetation, will limit the capacity of this section of the system as the retarding basin fills.

A Hec Ras model of the proposal suggests that this design initiative should see approximately 100 mm breakaway flow from the wetland connection channel into the Plains Grassy Wetland area in the 3 month event. In the 1 Year ARI event this increases to about 300 mm breakaway flow. This approximately replicates the expected breakaway flow under existing conditions (considering the smaller channel and smaller design flow). A series of 300 mm pipes located under the proposed road will convey this sheet flow to Plains Grassy Wetland areas located south of the road.

As such, regular wetting of this existing Plains Grassy Wetland area should continue to occur, even with the proposed wetland and road construction. The grasslands are currently, and will in the future, be watered by rainfall falling on the grassland areas themselves and flow exceeding the capacity of the existing drain while the storage is filling. Water "ponding" at depth for extended periods (say a day or more) does not occur (and should not) occur during frequent events, either now or in the future. Significant ponding, due to outlet constriction, only really occurs in events of greater magnitude than about a 20 Year ARI storm.

6. Predicted Ultimate Wetland Velocities.

The Hec Ras model detailed above was used to assess predicted wetland velocities during the 100 Year ARI event.

During this event, the retarding basin is significantly affected by backwater from its outlet culverts (as it should be). This effect results in 100 Year ARI design velocities over the wetland area being in the order of 0.25 m/s (max).

100 Year ARI velocities over the proposed wetland and sediment pond are less than 0.5 m/s and therefore meet the current requirement for extreme velocities as defined by the MWC Wetland Design Guidelines (April 2010).

7. Sediment Pond Design

The proposed strategy aims to provide primary treatment to the three catchments serviced Pipelines 1 – 3. Pipeline 1 is serviced by the Existing Brunt Road sediment pond and wetland system.

Pipelines 2 and 3 are proposed to be serviced by two sediment ponds within the Grassland Retarding Basin site. It should be noted that the catchment upstream of Prices Highway is expected to receive at least primary treatment through WSUD proposed within the “Clay Pit” retarding basin area (Officer DSS proposals).

When incorporating wetland systems into any subdivision a crucial aspect of the design process is to ensure adequate sediment pond pre-treatment. If course sediments are not trapped prior to entry to the wetlands systems, the operational life of the downstream wetland will be drastically reduced.

The two sediment ponds proposed are located at the upstream end of the wetland system. Both sediment ponds are 900 m^2 and 1800 m^3 (i.e. 2 metres deep). The systems have been sized given available site area.

Both sediment ponds meet the current MWC design criteria. In particular:

- They are sized to remove at least 95% of ≥ 125μm sediment in the 3 month ARI event (Table 8 details the system efficiency),
- 100 Year ARI flow velocities are below 0.5m/s (see Section 6 above),
- The functional design allows for:
  - access ramps into the pond at <1 in 8 slope (V:H),
  - tracks to all hard stand areas (3m wide),
  - an adequate area for dewatering and short term storage of removed sediments,
  - crushed rock bases extending 300mm vertically above the base, and
  - 1 in 5 batters and edge vegetation above and below the water line for safety batters.

It should be noted that balance pipe systems (which can be used to isolate the sedimentation ponds from the macrophyte zones during maintenance periods) are not specified. This is because there is not enough space in this very constructed site to accommodate this feature. Maintenance of the sediment ponds will be required to be achieved via pumping when required. Pump pits may be required to be specified at the detailed design stage of the project.

Table 8 Sediment Pond Sizing

Fair and Geyer Equation – Equ 10.3 WSUD Stormwater Technical Manual (2004)

$$R = 1 - \left[1 + \frac{1}{n}\cdot\frac{v_s}{Q/A}\cdot\frac{(d_e + d_p)}{(d_e + d^*)}\right]^{-n}$$

$\lambda = 1 - 1/n$; $n = \frac{1}{1-\lambda}$

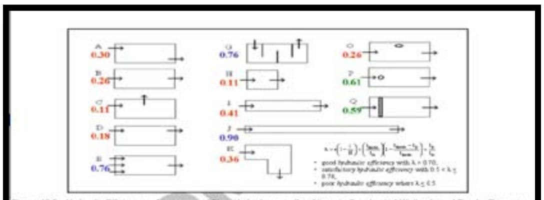

Figure 10.5 Hydraulic Efficiency – A measure of Flow Hydrodynamic Conditions in Constructed Wetlands and Ponds. Range is from 0 to 1, with 1 representing the best hydrodynamic conditions for stormwater treatment [Source: Australian Runoff Quality, 2003]

Source: WSUD Engineering Procedures:

R = fraction of Initial Solids Removed = 80 - 90 % typ.

R	= fraction of Initial Solids Removed = 80 - 90 % typ.
d_p	= Depth of permanent pool
d_e	= Extended detention depth above permanent pool
d^*	= depth below permanent pool sufficient to retain particles (lower of 1.0m or d_p)
Q	= design flow (Typically 3 month, 6 month or 1 year flow)
A	= Basin Surface Area
n	= turbulence parameter (see above) = 1 for significant short circuiting and turbulence; = 5 for insignificant short circuiting and turbulence
v_s	= setting velocity for particles

Target = very fine sand

Vs = 0.011 m/s

d_e = 0.4 m
d_p = 2.0 m
d^* = 1.0 m

$\frac{(d_e+d_p)}{(d_e+d^*)}$ = 1.7

Q3mth = 0.5 m/s (RULE OF THUMB GIVEN 5 YEAR FLOW)
A = 900 m^2

$\frac{V_s}{Q/A}$ = 19.80

λ = 0.26 pond shape assumption (no rock weir required)
n = 1.35 (therefore low efficiency)

Fraction of Initial Solids Removed
R = 99%

Requirement: Melbourne Water Usually Require R = 95% for a 125 micrometer particle

Cleanout Frequency

Catchment Area =	42.4	ha	Just urban catchment considered
Sediment load =	1.6	m^3/ha/yr	(Willing and Partners 1992 urban load)
Gross Pollutant Load =	0.4	m^3/ha/yr	(Alison et al 1998)
Actual basin depth =	2	m	
Actual Basin area =	900	m^2	

Therefore, cleanout frequency required = $\frac{R(1.6+0.4)C_{atchment}}{0.67 d_{basin} * A_{basin}}$ = 0.07 per year

14.2

Assumes cleanout when basin 2/3 full

8. Stormwater Pollutant Modelling

Urban stormwater quality management for the protection of the downstream receiving bodies is a requirement of all new urban development. The water quality objectives are detailed below.

Suspended solids -	80% retention of the typical urban annual load
Total Phosphorus -	45% retention of the typical urban annual load
Total Nitrogen -	45% retention of the typical urban annual load
Litter -	70% reduction of the typical urban annual load

The proposed sediment pond/wetland system proposed within the Grasslands Retarding Basin, is in fact a retrofit design. It's primary function is NOT, stormwater pollutant treatment. It has been proposed to:

- Complement the existing ecological attributes of the site, and
- Provide adequate pipe outfall invert levels.

The existing Officer DSS is also a DSS which was initiated well before wide scale application of WSUD. AS such, it is assumed that WSUD initiates within the catchment may not meet current best practice. However, all effort should be made to maximise stormwater treatment given available space allocations and known physical constraints.

A MUSIC (Version 4) model has been created to assess the current WSUD initiatives to the railway outfall. Current initiatives include:

- The existing Brunt Road Sediment Pond and Wetland system treating Sub Areas K and L. Detailed plans of this element were not available. However given contour and aerial photo information a 1000 m^2 sediment pond and 2000 m^2 wetland is assumed (ED = 500 mm, 48 hours ED). It should be noted that this element was designed before 2000 and current wetland design guidelines.
- The existing Kiln Clay Pit areas. It is assumed that heritage constraints will result in little change in form to these elements. As such both are modelled as 7000 m^2 ponds treating Subareas A – F.
- The proposed Grassland Retarding Basin system sediment ponds and wetland systems. Both sediment ponds are 900 m^2 and 2 metres deep. The effective wetland area (excluding the sediment pond areas) is about 7500 m^2 (ED = 400 mm, ED time = 72 hours).

Figure 11 details the MUSIC model developed for the catchment.

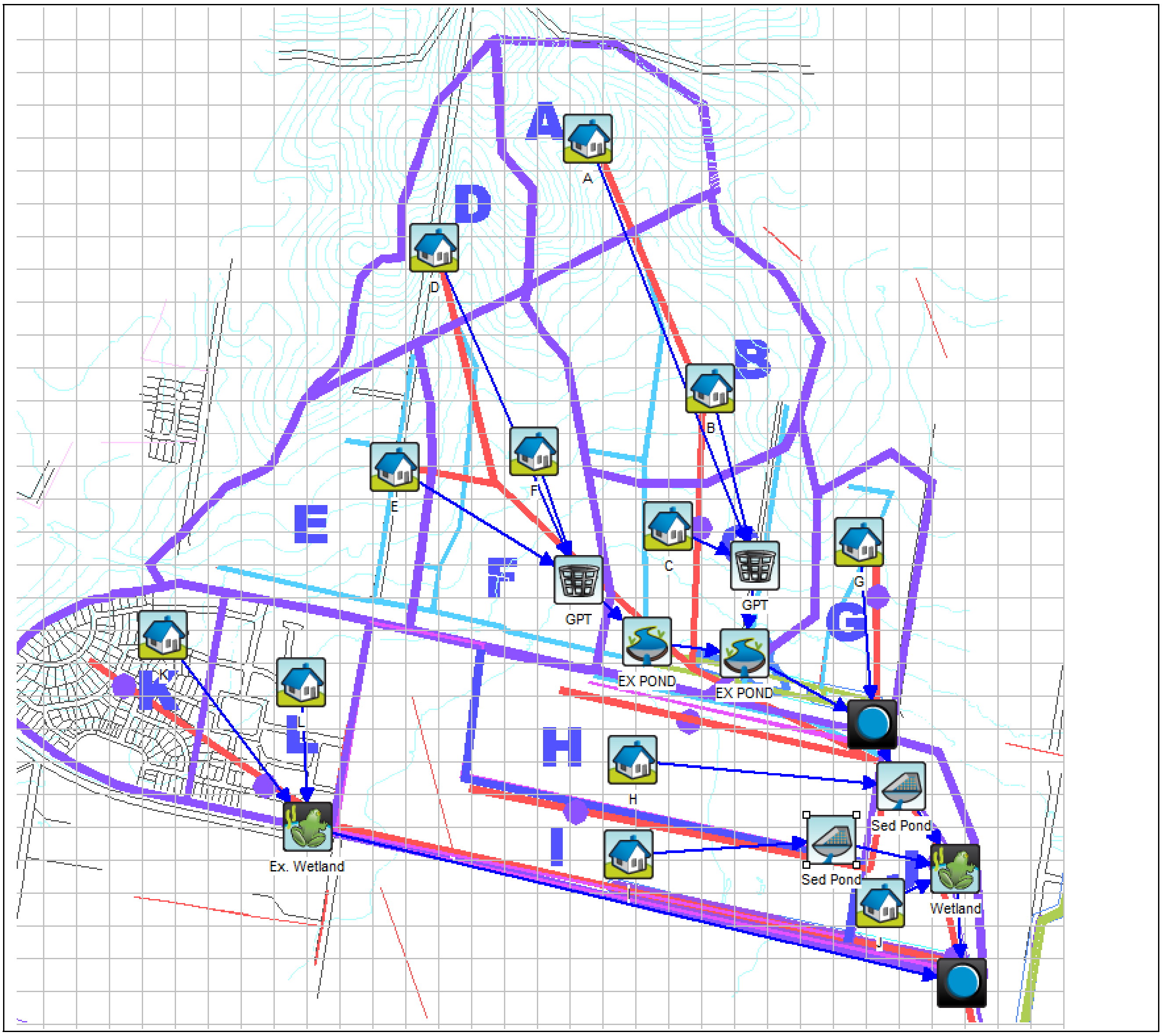

Figure 11 MUSIC Model

Catchment Assumptions are as detailed in Section 4 above and are based on the RORB model specifications.

The MWC reference gauge rainfall and evaporation data available for in Koo Wee Rup (2004, 800 mm/yr) at 6 minute intervals was utilised. This is the MWC reference gauge for this area of Melbourne

The results from the modelling are provided below.

Table 9 MUSIC Modelling Results at Railway

	Sources	Residual Load	% Reduction
Flow (ML/yr)	1.61E3	1.58E3	1.7
Total Suspended Solids (kg/yr)	298E3	123E3	58.7
Total Phosphorus (kg/yr)	613	330	46.1
Total Nitrogen (kg/yr)	4.56E3	3.50E3	23.3
Gross Pollutants (kg/yr)	53.9E3	0.00	100.0

As shown, the load reduction objectives for TSS, TP, TN and litter are not met by the proposed catchment WSUD initiatives.

However, the initiatives are providing good primary and secondary treatment of stormwater pollutants to the railway. Thus, the DSS initiatives proposed can be used to supplement downstream wetlands and possible site scale WSUD application in this catchment.

10. Summary

The proposed functional design presented by Stormy Water Solutions for the subject site represents current best practice WSUD principles and practices.

This report:

- o Details a catchment strategy required to ensure cost effective development of areas west and north of the Grassland Retarding Basin,
- o Details the concept design of incoming pipelines to the retarding basin site, and
- o Details the functional design requirements of the major wetland feature proposed within the retarding basin site.

The initiatives are predicted to provide good primary and secondary treatment of stormwater pollutants to the railway. Thus, the DSS initiatives proposed can be used to supplement downstream wetland and possible site scale WSUD application in this catchment.

In addition the initiatives ensure

- The railway culvert does not require to be upgraded (to either increase capacity or lower the existing invert level),
- Accommodation of road alignment changes required as part of the current Council PSP process, especially the requirement for a road traversing the retarding basin site,
- Existing and future subdivisions can be adequately protected from the 100 Year ARI flood level,
- Maximisation of grassland retention on site, and
- Ultimate drainage assets which complement the built environment aesthetics and the local environment and ecology.

The proposed functional design has been discussed with Cardinia Shire Council. Council have indicated that they generally support the drainage concepts detailed within this report. Investigations have been performed to ensure the retarding basin and catchment planning can aid in the development of the Officer PSP.

It is requested that:

- Melbourne Water Corporation AND Cardinia Shire Council provide approval in principle for the Grasslands Retarding Basin functional design, and
- Melbourne Water Corporation provide this report to DSE for formal comments.

11. 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
DSS	Melbourne Water Corporation Development Services Scheme
Inlet Pond	See Sediment Pond
Hectare (ha)	10,000 square metres
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
Megalitre (ML) (1000 cubic metres)	1,000,000 litres = 1000 cubic metres Often a unit of water body (eg pond) size
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
Retarding basin	A flood storage dam which is normally empty. May contain a lake or wetland in its base
Normal Water Level	Water level of a wetland or pond defined by the lowest invert level of the outlet structure
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
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
Extended Detention	Range of water level rise above normal water level where stormwater is temporarily stored for treatment dor a certain detention period (usually 48 – 72 hours in a wetland system)
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 treatment swale).
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 elements which are used to collect TSS, TP and TN. Usually incorporated an normal water level (NWL) below which the system is designed as shallow

	marsh, marsh, deep ,marsh and open water areas.