Hydrological and Environmental Engineering

Pakenham East Precinct Structure Plan

Deep Creek Corridor Proposals

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Contents

1. Introduction

In March 2013, Stormy Water Solutions produced a report entitled "Pakenham East Precinct Structure Plan, Proposed Drainage Strategy, Draft Report". This 2013 report considered the major drainage, flooding and water quality management issues within the Pakenham East Precinct Structure Plan (PSP) area to define potential land take requirements required by major drainage assets.

As part of the 2013 work Stormy Water Solutions developed various strategy options for consideration. In this way, council could incorporate various scenarios in relation to drainage requirements and ultimately adopt a PSP formulation which optimises all PSP objectives, not just the drainage requirements.

Melbourne Water Corporation (MWC) subsequently commented on the draft report and options. Of particular concern was the corridor proposed for Deep Creek. The current PSP Proposals generally show:

- a 50 metre reserve on the west of Deep Creek and a 100 m reserve of the east of Deep Creek downstream of Princes Highway, and
- 100 m reserve of the east of Deep Creek upstream of Princes Highway
- An assumption that any future development west of Deep Creek upstream of Princes Highway would require a 50 m reserve to be consistent with the above. However, in the interim, the UFZ line (which is consistent with the declared flood plain line) could be assumed.

The two major issues identified by MWC in relation to the Deep Creek Corridor were:

- By setting the development line on either side of Deep Creek, as per Councils 2013 proposal, flows will be restricted and future development will be required to be filled to MWC standards to ensure adequate flood protection. This may result in a small increase in flood levels, and
- The PSP plan did not appear to address the breakaway flow from Deep Creek towards the south-east, where flows outfall at the Princes Freeway. Melbourne Water suggested that this could be addressed by either:
    a) Upgrading (/ increase the capacity of) Deep Creek downstream of Ryan Road, including upgrading the bridge; or
    b) Set aside land in the FUS plan to allow for breakaway flows to extend down to the proposed retarding basin at the Princes Freeway.

This report addresses the above two issues to clearly show that the Deep Creek Corridor proposals are sufficient to allow future works to address the above concerns. This report also proposals some downstream works (in line with (a) above) to ensure current flood protection provisions downstream of Ryan Road are not compromised.

2. Current PSP Proposals in Relation to Deep Creek

It is proposed to retain Deep Creek and its riparian zone in their current form. However, ongoing waterway management will occur in line with current and existing ecological and landscape requirements.

In line with current PSP proposals, the Deep Creek corridor is proposed to incorporate:

- a 50 metre reserve on the west of Deep Creek and a 100 m reserve of the east of Deep Creek downstream of Princes Highway, and
- 100 m reserve of the east of Deep Creek upstream of Princes Highway
- An assumption that any future development west of Deep Creek upstream of Princes Highway would require a 50 m reserve to be consistent with the above. However, in the interim, the UFZ line (which is consistent with the declared flood plain line) could be assumed.

The proposed reserve encompasses the entire Deep creek riparian vegetation and the existing Deep Creek Road (upstream of the Highway).

Any future development must incorporate filling to required MWC standards adjacent to the creek to ensure adequate flood protection. At this stage fill requirements are assumed to be 600 mm above the flood levels determined given ultimate reserve requirements. Fill requirements may vary in the order of between 600 to 1200 mm adjacent to Deep Creek. It is proposed to grade the fill down to natural surface level over (say) 100 metres, creating, in effect, a very wide, flat levee adjacent to the creek.

The Deep Creek Princess Highway Culvert has enough capacity to convey the future and existing 100 Year ARI flow (See Appendix B).

This report expands the above proposals and identifies additional corridor works required to address the issues highlighted in Section 1 above.

3. Hydrological Modelling - Deep Creek

Hydrological Modelling using the RORB model was developed for this study by SWS to estimate flood flows within Deep Creek. MWC have advised that the flood plain was declared assuming a 100 Year ARI flow of 43 m^3/s. The RORB model was developed to:

- Confirm this flow assumption,
- Account for flow reductions in upstream reaches, and
- Account for catchment development as per PSP proposals.

The analysis below only considers the 100 Year ARI storm events. Consideration of this event will provide realistic site delineation of the Deep Creek Corridor extent. Appendix A details the RORB model control vector. As detailed subareas H and I incorporate a fraction impervious of 0.6 to account for future development in these areas (accounting for future council reserves and the existing UFZ north of Princes highway and west of Deep Creek.

The regional parameter set developed by Melbourne Water for the South East region of Melbourne was utilised. This relationship is detailed below. Table 1 details the RORB results for Deep Creek

$K_c = 1.53A^{0.55} = 7.0$ (area = 15.9 km^2)
m = 0.8
Initial loss = 10 mm
Pervious area runoff coefficient, 100 year = C_{perv} = 0.6 mm
Pakenham Upper rainfall intensities were utilised.

Table 1 RORB Results

Location	100 Year ARI Design Flow (m3/s)	Critical Duration (hours)		
End Reach 10	24.3	9		
Upstream Reach 12	27.2	9		
Reach 13 input	8.1	1	6.6	(9hr)
Upstream Reach 14	33.8	9		
Reach 15 input	11.1	2	6.9	(9hr)
Deep Creek at Princes Highway	40.7	9		
Deep Creek at Ryan Road	40.4	9		
Deep Creek into Deep Creek RB	42.8	9		

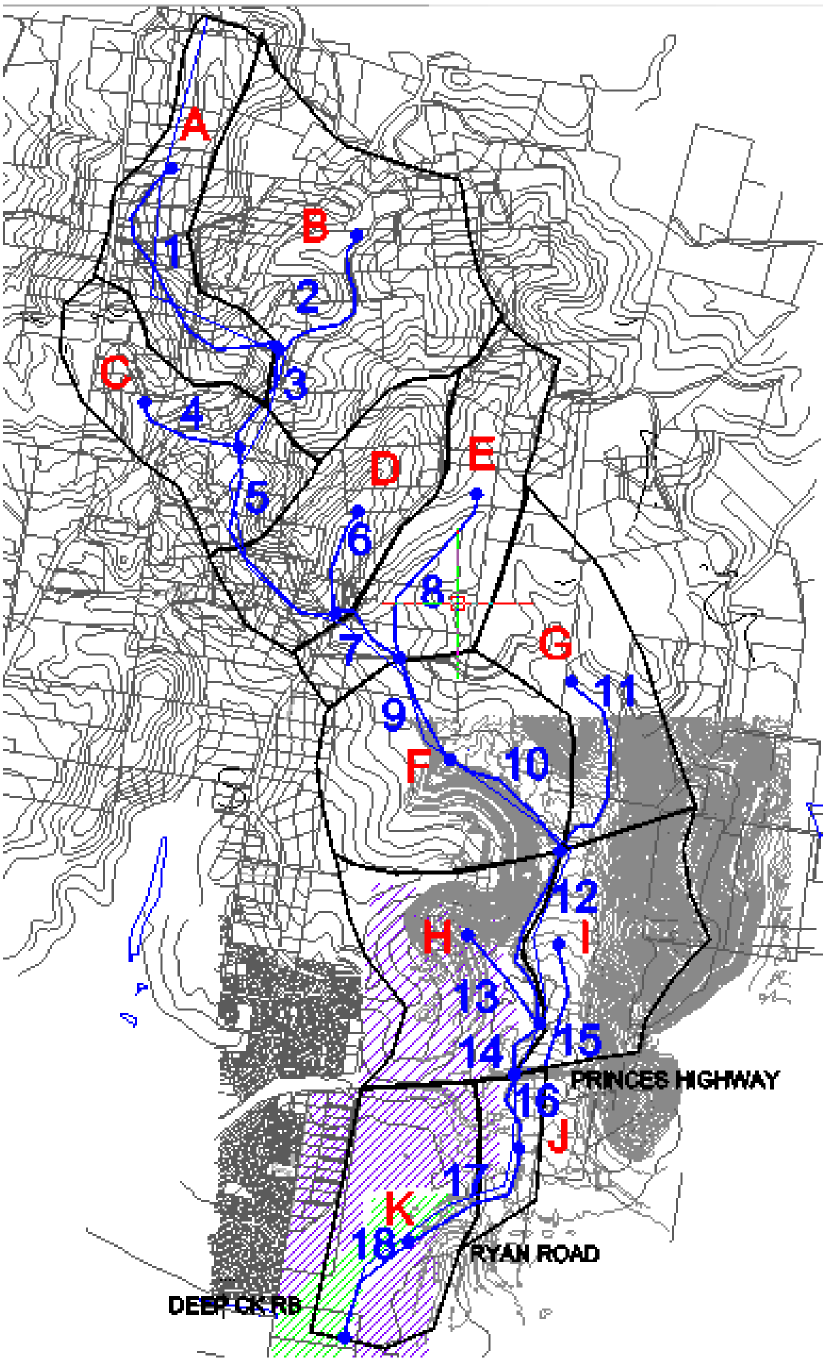


Figure 1 Deep Creek RORB Model

The rational method calculated a 100 Year ARI flow at the Deep Creek Retarding basin of 38.2 m^3/s (C=0.4, time of concentration = 3 hours. The DSE regional flow estimate graphs for rural catchment calculates a 100 Year ARI flow at the Deep Creek Retarding basin 38.5 m^3/s. The flow of 42.8 m^3/s is consistent with previous MWC assumptions (43 m^3/s as advised by Mark Warren in September 2014).

Given the above the flows above are considered reasonable to adopt in regard to assessing the flooding implications along the Depp Creek corridor upstream of the Deep Creek Retarding Basin.

4. Hec Ras Modelling - Existing Conditions

4.1 Deep Creek Retarding Basin to Ryan Road

The Hec Ras model described below was used to assess existing flood levels downstream of Ryan Road. This was done so that a “base” case could be determined to assess any potential PSP implications downstream of Ryan Road.

This model was constructed utilising:

- The design flow detailed above 43 m^3/s,
- A starting water level of 23.2 m AHD which is the declared flood level at Section 0),
- 0.5 metre Lidar information provided by Council,
- DVA drawing set 1606/1 which detailed flood mitigation works (1989) downstream of Ryan Road,
- Manning n of 0.05 for flood plain areas associated with paddocks or the golf course,
- Mannings n values of 0.05 to 0.06 for cleared drainage lines, and
- Mannings n values of 0.09 for drainage paths incorporating in stream vegetation.

Examination of the Lidar information suggested that the northern levee bank works directly downstream of Ryan Road were not included in the 1989 design plan set. The declared flood plain plans suggest the levee works were actually completed about 1992. As noted on one of the MWC declared flood plain plans, the aim of these works was to provide 100 year protection to the low density properties located north of Deep Creek, directly downstream of Ryan Road. However, other information suggests a capacity less than the 100 year flow (35 m^3/s as per the levee design plans).

Given the above, the cross section in this area of the creek were derived using a combination of the 1989 design plan information and the recent Lidar survey information.

The above is considered accurate enough to:

- Assess if existing flood levels are consistent with the declared flood levels, and
- To assess the impact of upstream PSP proposals along this section of creek.

However, actual flood levels should be determined at the functional design stage of the project given detailed site survey information.

In addition to the above a flow of 18 m^3/s was also run through the model. This was done to clearly show that the declared flood levels were based, conservatively, assumed that the total design flow of 43 m³/s and did not account for any breakaway flow to the south upstream of Ryan Road. This is considered a reasonable assumption as:

- The email advice from Keith Boniface of Melbourne Water dated 1/2/13 stating " the breakaway flow at the south end adjacent to Ryan Road, I think, has been eliminated or at least reduced in subsequent works",
- hand written notes on the MWC declared flood level plan indicate some filling upstream of Ryan Road and construction of a house on Canty Land may limit breakaway flow south, and
- A large proportion of any breakaway south may actually be directed west to Ryan Road due to the relatively hydraulic smoothness of Canty Lane as opposed to the surrounding land types.

Figure 2 shows the calculated flood levels assuming a design flow of 43 m³/s. Table 2 details the calculated flood levels (43 m³/s) compared with the MWC declared flood levels.

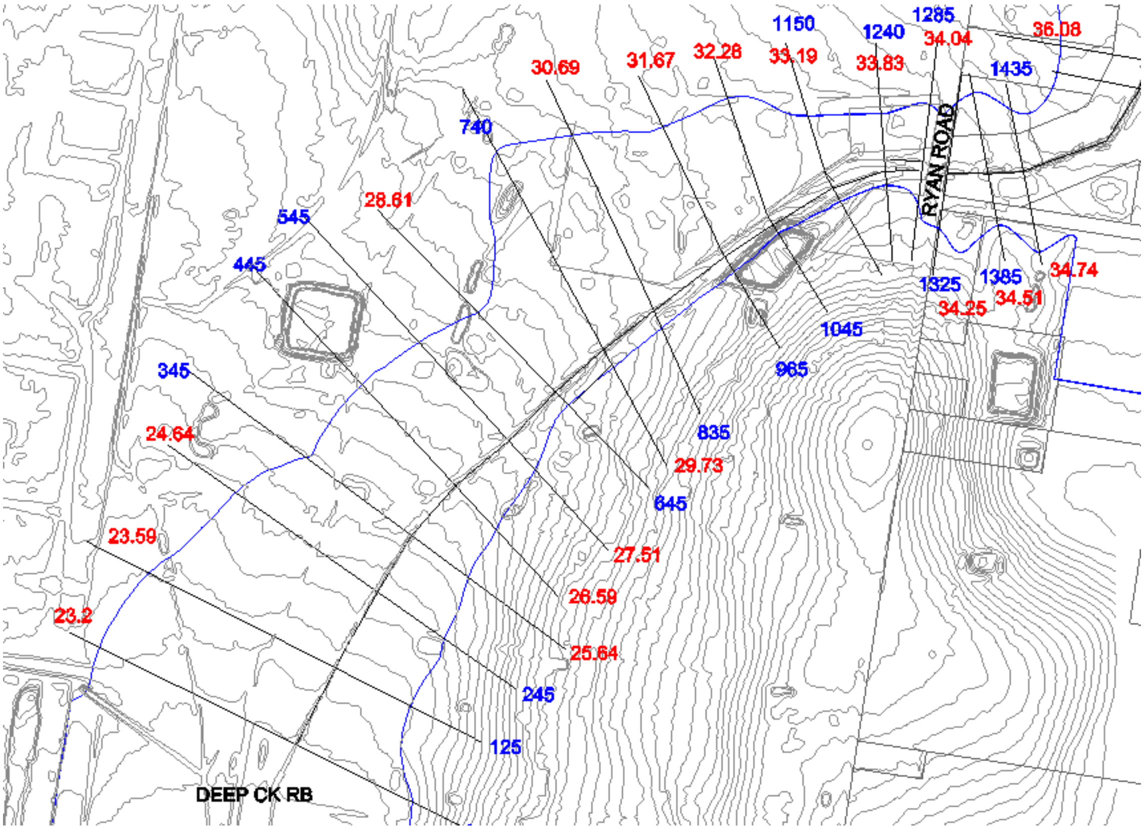


Figure 2 **Deep Creek - Existing Flood Levels Downstream of Ryan Road**
Blue text – Hec Ras Chainage
Red Text = 2014 Calculated flood level (existing situation)
Blue line – declared flood plain extent which gives an indication (only) of the extent of inundation in the 100 Year ARI event.

Table 2 Hec Ras Results (43 m^3/s) compared with Declared Flood Plain Levels

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
1285	33.7	43	34.04	340
1240	33.26	43	33.83	570
1150	33.19	43	33.19	0
1045	32.63	43	32.28	-350
965	31.68	43	31.67	-10
835	30.85	43	30.69	-160
740	29.75	43	29.73	-20
645	28.61	43	28.61	0
545	27.62	43	27.51	-110
445	26.71	43	26.59	-120
345	25.6	43	25.64	40
245	24.61	43	24.64	30
125	23.5	43	23.59	90
0	23.2	43	23.2	0

The results indicate that the expected 100 Year ARI flood levels are generally at or below the declared flood plain levels.

Flood levels are probably lower between chainages 835 and 1045 due to the declared flood levels possibly not accounting for the constructed on line pond in this area (the pond was constructed in 1989, and the survey used to define the flood plain for the flood plain declaration was completed in 1978).

In addition, flood levels are higher just downstream of Ryan Road, possibly due to the flood levels possibly not accounting for the constructed northern levee in the area (again this levee was only constricted in 1992). As shown in Figure 3 below, it is estimated that the levee just contains the 100 Year flow of 43 m^3/s (as was inferred in the declared flood plain plan set).

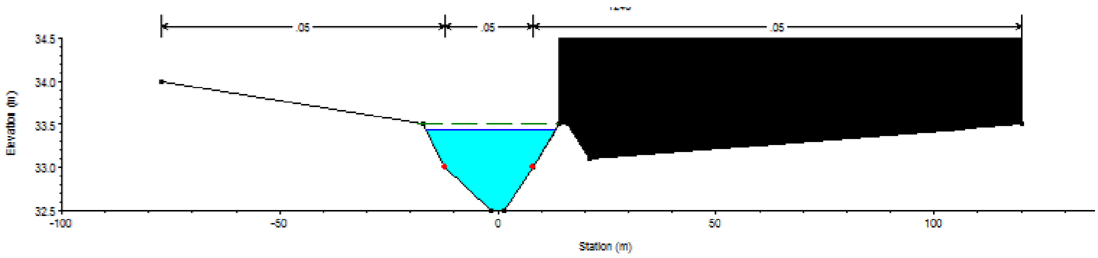


Figure 3 Ch 1240 - Looking Downstream

Table 3 details the calculated flood levels (18 m^3/s) compared with the MWC declared flood levels. This analysis was undertaken to investigate if the declared flood levels accounted for any breakaway flow to the south upstream of Ryan Road. As detailed, calculated flood levels are generally much lower than the declared flood levels, indicating that MWC, conservatively, assumed no breakaway flow when setting flood levels in this area in the past. This is considered a prudent assumption the issues highlighted above.

Table 3 Hec Ras Results (18 m^3/s) compared with Declared Flood Plain Levels

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
1285	33.7	18	33.63	-70
1240	33.26	18	33.45	190
1150	33.19	18	32.72	-470
1045	32.63	18	31.73	-900
965	31.68	18	31.5	-180
835	30.85	18	30.46	-390
740	29.75	18	29.63	-120
645	28.61	18	28.48	-130
545	27.62	18	27.38	-240
445	26.71	18	26.47	-240
345	25.6	18	25.55	-50
245	24.61	18	24.53	-80
125	23.5	18	23.51	10
0	23.2	18	23.2	0

The results do show that fill and flood levels downstream of Ryan Road do account for a design flow in this area of 43 m^3/s, not 18 m^3/s. As such, the PSP proposals in regard to assuming minimal breakaway flows to the south upstream of Ryan Road should not impact on flood protection provisions in this area.

It is considered that enough work has been completed for Council to move forward in confidence in regard to the PSP proposals in regard to reserve and overland flow path provisions upstream of Ryan Road. However, detailed design of the Deep Creek Reserve Corridor upstream of Ryan Road (see Section 5 below) should include detailed survey and updated modelling of the channel and levee downstream of Ryan Road to confirm the above results.

4.2 Existing Ryan Road Culvert System

The declared flood level directly upstream of Ryan Road is 34.2 m AHD.

A culvert and weir flow analysis (Appendix B) calculated a 100 Year flood level (assuming a design flow of 43 m^3/s) of 34.25 m AHD (15 m^3/s in the culvert system and 28 m^3/s over the road). If 18 m^3/s design flow is assumed a 100 Year ARI flood level of 34.1 m AHD (11 m^3/s in the culvert system and 7 m^3/s over the road).

Again, the results do show that fill and flood levels directly upstream of Ryan Road do account for a design flow in this area of 43 m^3/s, not 18 m^3/s.

However the results do indicate that there is an argument to upgrade the Ryan Road culvert system given the development which has occurred in the area over the last 25 years and the potential development in the PSP area. Flow over the road of $28m^3/s$ may be justified in a rural context, but possibly not when the population using the road drastically increases.

4.3 Ryan Road to Princes Highway

The Hec Ras model described below was used to assess existing flood levels between Ryan Road and Princes Highway. Again, this was done so that a "base" case could determine to assess any potential PSP implications between Ryan Road and Princes Highway.

This model was constructed utilising:

- The design flows detailed in Section 3,
- A starting water level of 34.25 m AHD which is the flood level calculate in Section 4.2 above at Section 1325),
- 0.5 metre Lidar information provided by Council, and
- Manning n of 0.05 for flood plain areas associated with paddocks,
- Mannings n values of 0.09 to 0.15 for to account for the vegetation in and adjacent to Deep Creek in this section of waterway.

The above is considered accurate enough to:

- Assess if existing flood levels are consistent with the declared flood levels, and
- To assess the impact of upstream PSP proposals along this section of creek.

Actual flood levels should be determined at the functional design stage of the project given detailed site survey information.

Figure 4 shows the calculated flood levels. Table 4 details the calculated flood levels compared with the MWC declared flood levels. Examination of the cross sections indicated that, although there are informal levees either side of Deep Creek, in this section of waterway, in the 100 Year event the system acts as one united cross section.

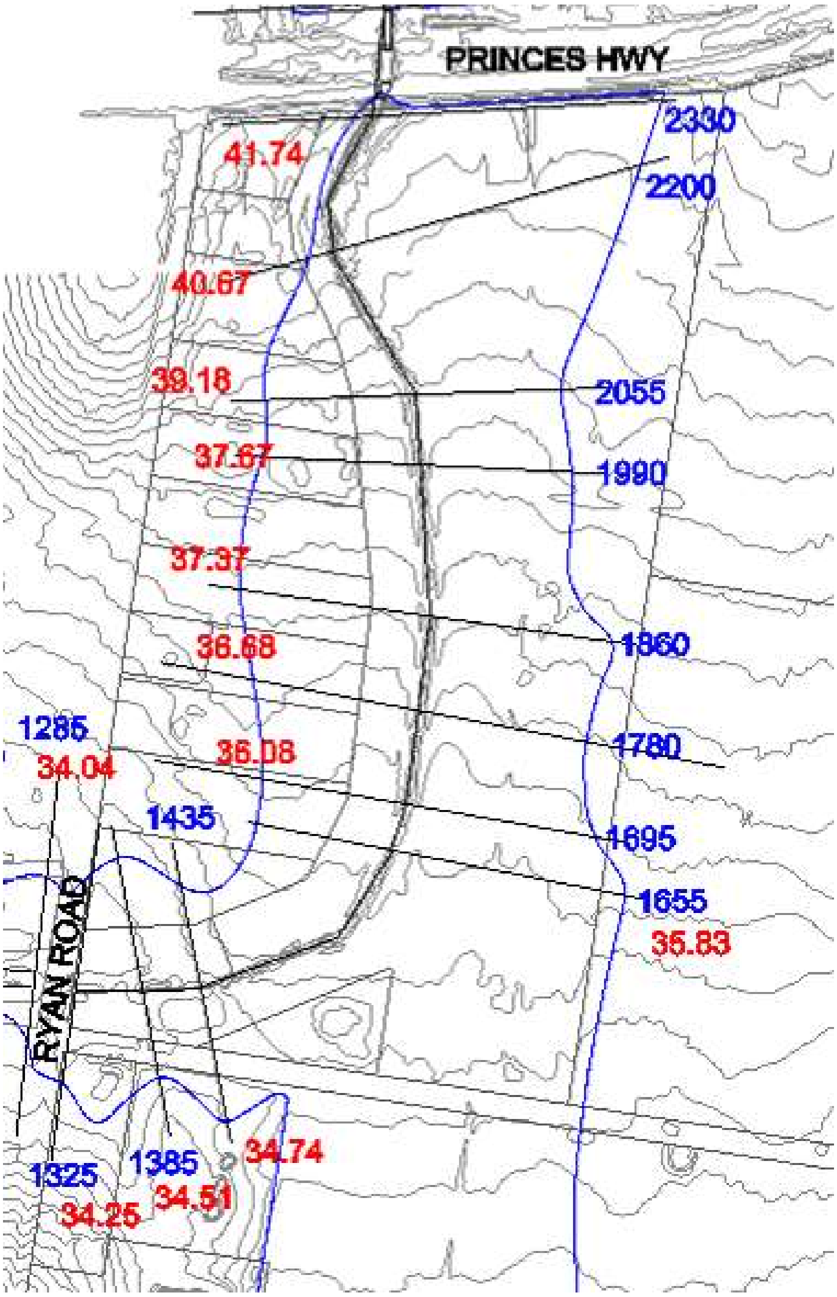


Figure 4 **Deep Creek - Ryan Road to Princes Highway**
Blue text – Hec Ras Chainage
Red Text = 2014 Calculated flood level (existing situation)
Blue line – declared flood plain extent which gives an indication (only) of the extent of inundation in the 100 Year ARI event

Table 4 **Hec Ras Results compared with Declared Flood Plain Levels**

Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)*	(m3/s)	(m AHD)	
2330	41.8	41	41.74	-60
2200	40.76	41	40.71	-50
2055	39.2	41	39.18	-20
1990	38.72	41	38.67	-50
1860	37.52	41	37.37	-150
1780	36.81	41	36.68	-130
1695	36.27	41	36.08	-190
1655	36.04	41	35.83	-210
1435	34.61	41	34.74	130
1385	34.4	41	34.51	110
1325	34.2	41	34.25	50

As detailed, flood levels are generally close to, or less than, the declared flood levels. This may be because the declared flood level plans (1978) may not have extended to include the full with of the flood plain. Flood levels may be slightly higher immediately upstream of Ryan Road, possibly due to a higher Manning n used than in the original flood plain declaration.

It is considered that the 2014 levels calculated above are reasonable to compare PSP impacts against (See Section 6 below)

4.4 Existing Princes Highway Culvert System

The declared flood level directly upstream of Ryan Road is 42.33 m AHD.

A culvert analysis (Appendix C) calculated a 100 Year flood level (assuming a design flow of 40.7 m^3/s) of 42.35 m AHD.

The culverts are not running under pressure in the 100 Year ARI event and do not need to be upgraded due to PSP implications.

4.5 Upstream of Princes Highway

The Hec Ras model described below was used to assess existing flood levels upstream of Princes Highway. Again, this was done so that a “base” case could determined to assess any potential PSP implications in this area of the Deep Creek corridor.

This model was constructed utilising:

- The design flows detailed in below,
- A starting water level of 42.35 m AHD which is the flood level calculate in Section 4.4 above at Section 2430),

- 0.5 metre Lidar information provided by Council, and
- Manning n values as detailed in Figure 6 below.

Again, the above is considered accurate enough to assess if existing flood levels are consistent with the declared flood levels and to assess the impact of upstream PSP proposals along this section of creek. Figure 5 shows the calculated flood levels. Table 6 details the calculated flood levels compared with the MWC declared flood levels.

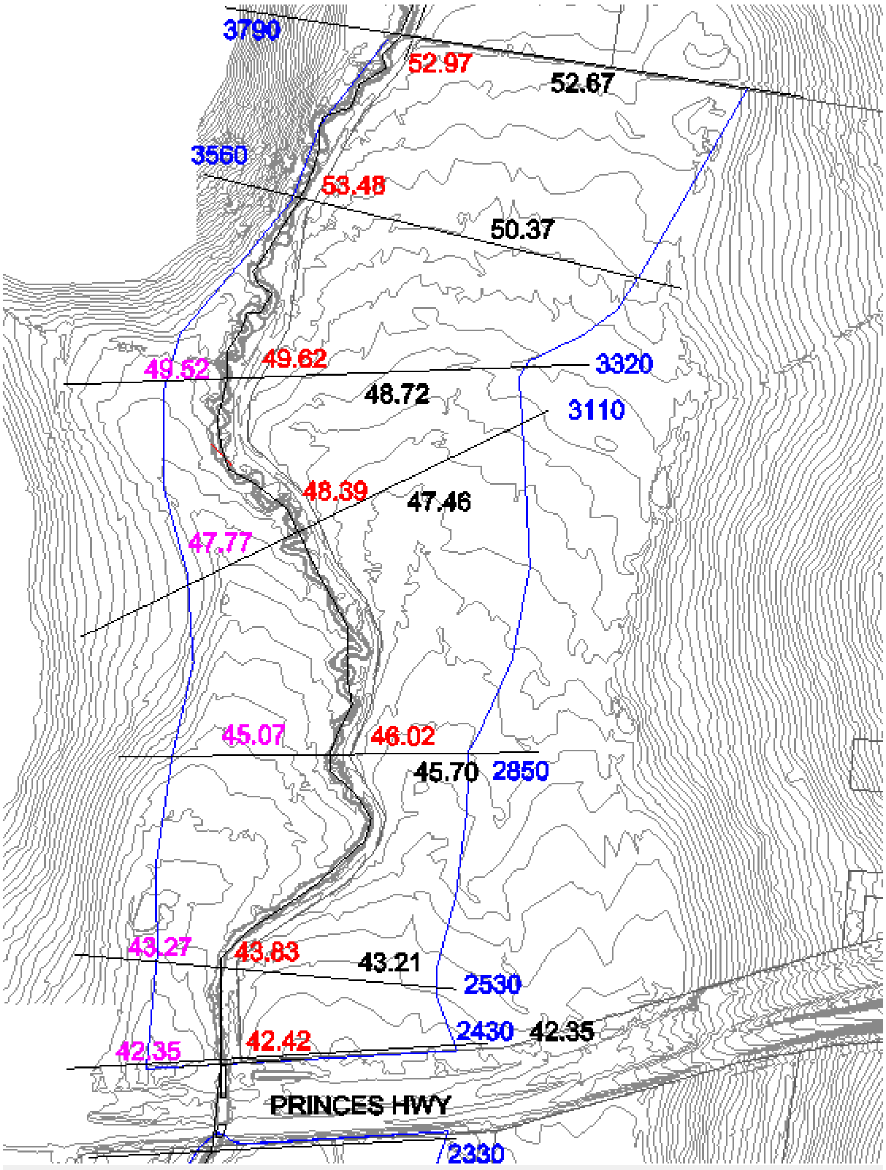


Figure 5 **Deep Creek - Upstream of Princes Highway**

Blue text – Hec Ras Chainage

Red Text = 2014 Calculated flood level in Deep Creek (existing situation)

Pink Text = 2014 Calculated flood level in Western Flood Plain (existing situation)

Black Text = 2014 Calculated flood level in Eastern Flood Plain (existing situation)

Blue line = declared flood plain extent (an indication only of the extent of inundation in the 100 Year ARI event)

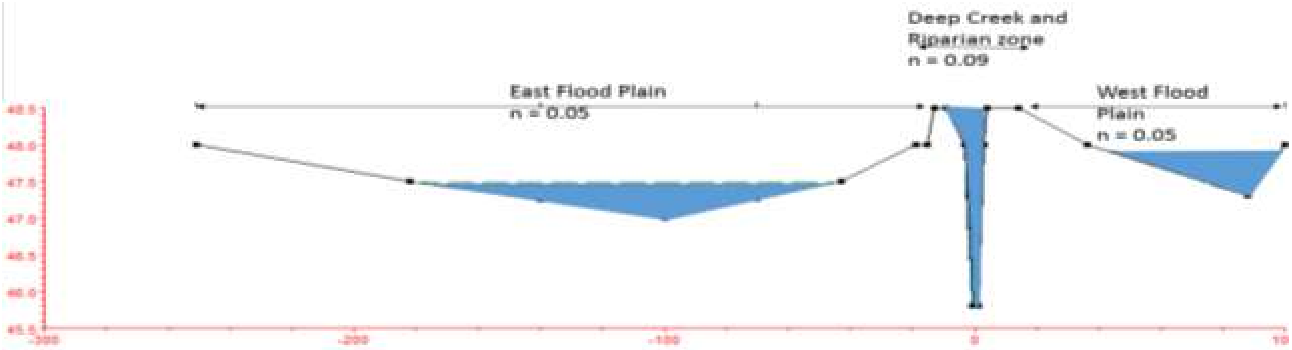


Figure 6 Deep Creek - Typical Cross Section Upstream of Princes Highway (3110)

As detailed below, it is clear that upstream of Princes Highway, the flows in Deep Creek, the eastern and Western floodplains act independently. That is, once flow enters the eastern or western flood plain, it cannot re-enter Deep Creek. Also, once flow leaves Deep Creek (by flowing over its adjacent levees or Deep Creek Road) it cannot re-enter the creek. The only Cross Section where flows combine is directly upstream of Princes Highway due to the table drain interaction.

Given this aspect of the flow process, three Hec Ras models were created as detailed for the channel, eastern and western floodplains. An iterative process determined how much flow could be contained within Deep Creek and where flow would be contained within the relevant flood plain. Flow splits are detailed below. Largely flows were for the 9 hour duration storm. However, higher flows than the 9 hour storm were used for the upper cross sections in the western flood plain due flows from the local catchment being higher than the 9 hour deep creek input at this location. This may explain the higher flood level produced at change 3320 in the western flood plain.

Table 5 Flow splits – Deep Creek upstream of Princes Highway

Cross Section	Total Deep Creek Contribution				Western Flood Plain		Eastern Flood Plain	
	Total Deep Creek Contribution	Western Flood Plain	***Channel***	Eastern Flood Plain	Assumed Flow from local catchment	***Total in flood plain including Deep Creek Breakaway***	Assumed Flow from local catchment	***Total in flood plain including Deep Creek Breakaway***
3790	27.2	0	***13***	14.2	0	***0***	3.5 (50% local catchment)	***17.7***
3560	27.2	0	***13***	14.2	0	***0***	5 (75% local catchment)	***19.2***
3320	27.2	0	***13***	14.2	8 (2hr)	***8 (2hr)***	6.9 (100 % local catchment)	***21.1***
3110	27.2	0	***13***	14.2	8 (2hr)	***8 (2hr)***	6.9 (100 % local catchment)	***21.1***
2580	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***
2530	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***
2430	27.3	3	***7.1***	17.2	6.9	***9.9***	6.9 (100 % local catchment)	***24.1***

All Critical Durations 9 hours unless specified)

Bold and italic - flows used in Hec Ras model

It should be noted, that in regard to flood protection under existing conditions, the relevant flood level is the flood level calculated in the flood plains, not the higher flood level in Deep Creek.

Table 6 Hec Ras Results compared with Declared Flood Plain Levels

Deep Creek Channel and Riparian Zone				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	52.64	13	52.97	330
3560	50.28	13	51.48	1200
3320	48.73	13	49.62	890
3110	47.62	13	48.39	770
2850	45.39	7.1	46.02	630
2530	43.47	7.1	43.83	360
2430	42.33	7.1	42.42	90
Eastern Flood Plain				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	52.64	17.7	52.67	30
3560	50.28	19.2	50.37	90
3320	48.73	21.1	48.72	-10
3110	47.62	21.1	47.46	-160
2850	45.39	24.1	45.7	310
2530	43.47	24.1	43.21	-260
2430	42.33	24.1	42.35	20
Western Flood Plain				
Chainage (m)	Declared Flood Level	Assumed 100 year Flow	100 Year Level	Change between Declared Level and 2014 Calculated Level (mm)
	(m AHD)	(m3/s)	(m AHD)	
3790	N/A	0		
3560	N/A	0		
3320	48.73	8	49.52	790
3110	47.62	8	47.77	150
2850	45.39	9.9	45.07	-320
2530	43.47	9.9	43.27	-200
2430	42.33	9.9	42.35	20

As detailed, flood levels in both the eastern and western flood plains are generally close to or less than the declared flood levels. Discrepancies would be due to the original analysis assuming all three systems act as one and possibly, variances in Mannings n assumptions

It is considered that the 2014 levels calculated above are reasonable to compare PSP impacts against (See Section 6 below)

5. Deep Creek Corridor PSP Implications

The March 2013 report highlighted the reserve requirements adjacent to Deep Creek. This previous work assumed that any flood mitigation or drainage augmentation works would be able to be contained within the 150 m reserve specified.

MWC identified two major issues identified by MWC in relation to the Deep Creek Corridor. These were:

- By setting the development line on either side of Deep Creek, as per Councils 2013 proposal, flows will be restricted and future development will be required to be filled to MWC standards to ensure adequate flood protection. This may result in a small increase in flood levels, and
- The PSP plan did not appear to address the breakaway flow from Deep Creek towards the south-east, where flows outfall at the Princes Freeway. Melbourne Water suggested that this could be addressed by either:
    - c) Upgrading (/ increase the capacity of) Deep Creek downstream of Ryan Road, including upgrading the bridge; or
    - d) Set aside land in the FUS plan to allow for breakaway flows to extend down to the proposed retarding basin at the Princes Freeway.

This report takes the PSP one step further than just setting a reserve requirement by specifying works within the proposed corridor which will address the above two issues. The aim is to show that works can be the proposed Deep Creek Reserve is wide enough to contain future works which can address the issues. Ultimate works may differ from those specified in this report.

Figures 7, 8 and 9 detail the concept design of the works proposed. Section 6 details the estimated effect on flood levels if these works are adopted.

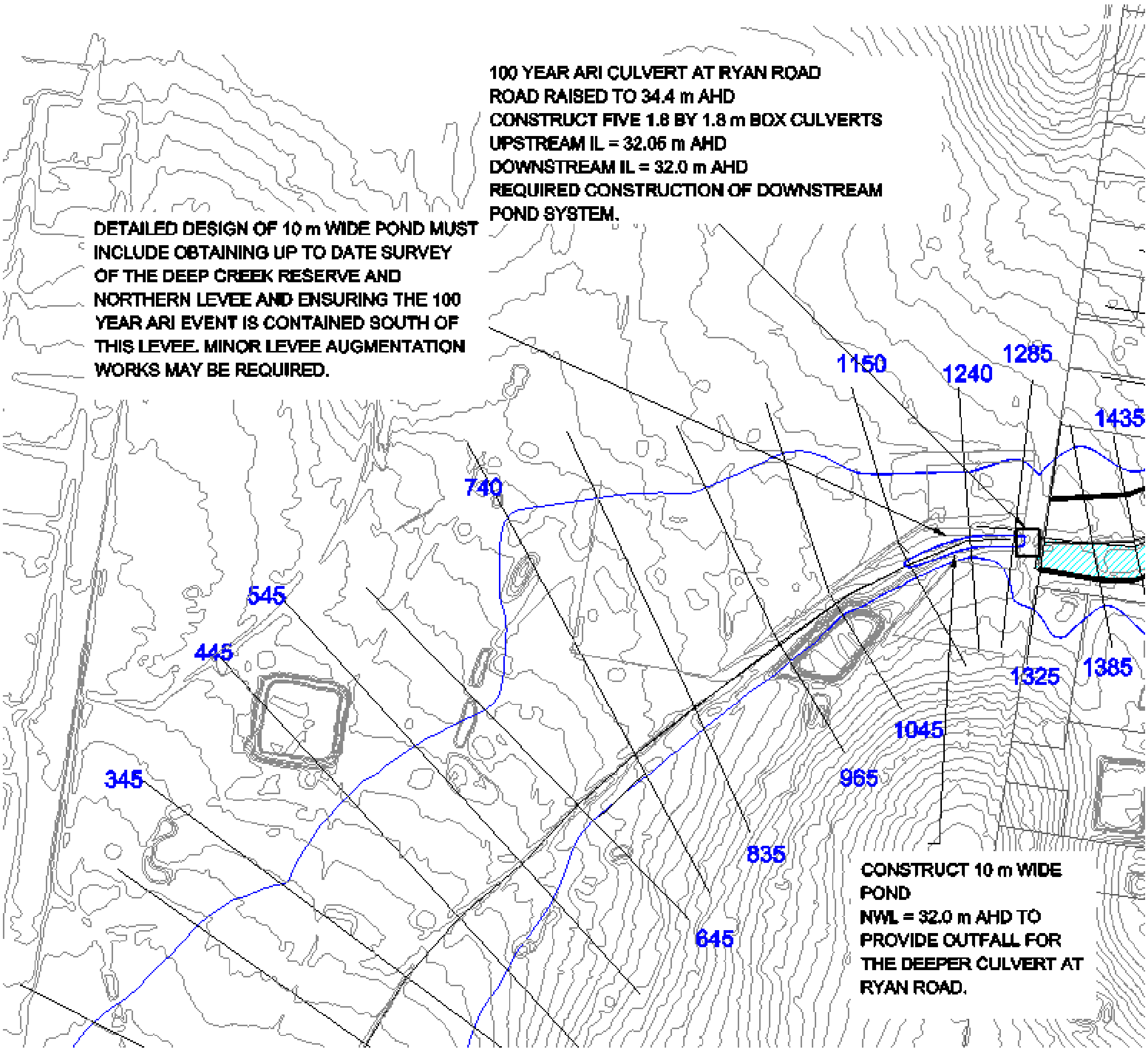


Figure 7 Possible Deep Creek Corridor Works Downstream of Ryan Road

Blue text – Hec Ras Chainage

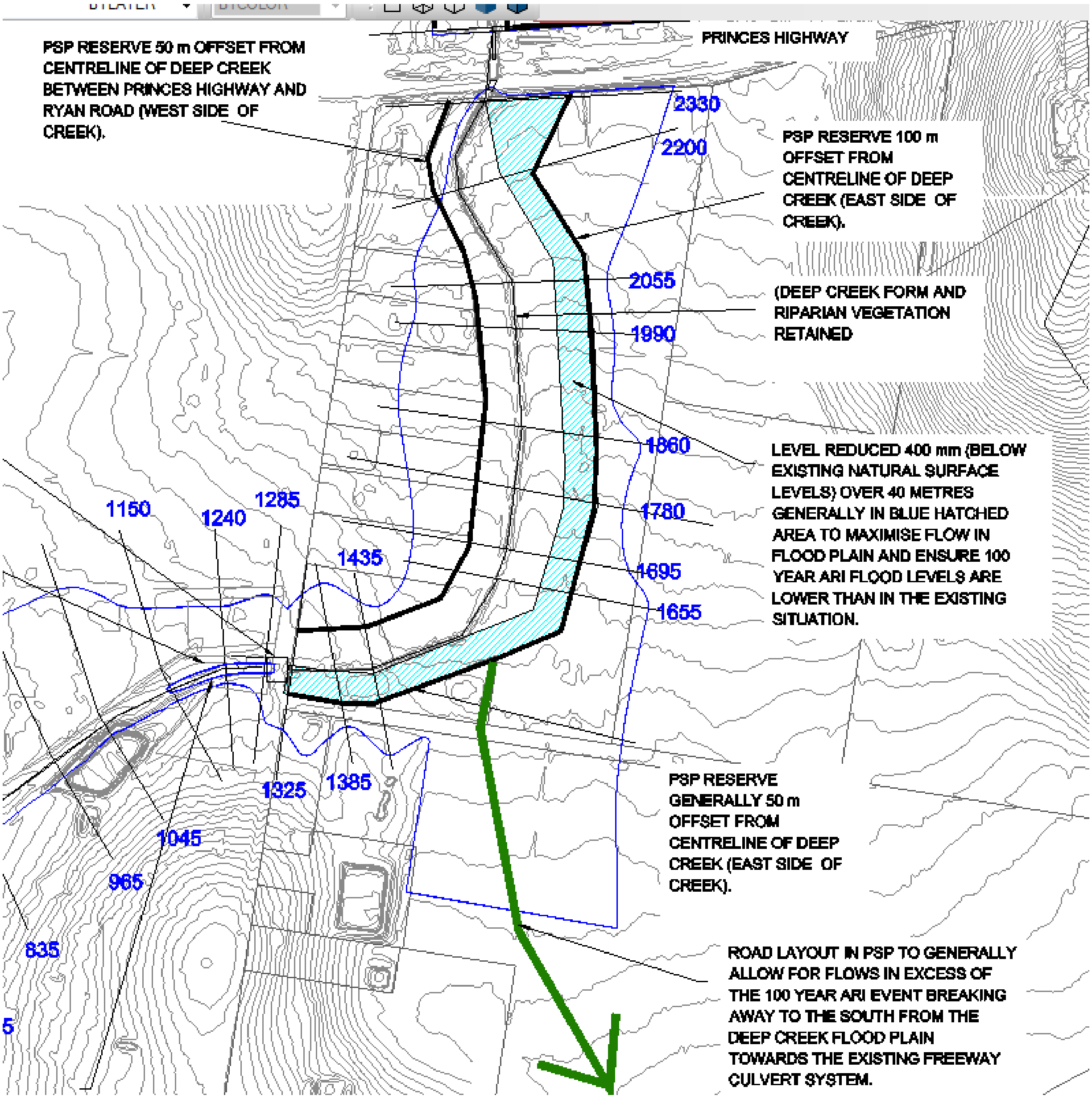


Figure 8 Possible Deep Creek Corridor Works - Ryan Road to Princes Highway

Blue text – Hec Ras Chainage

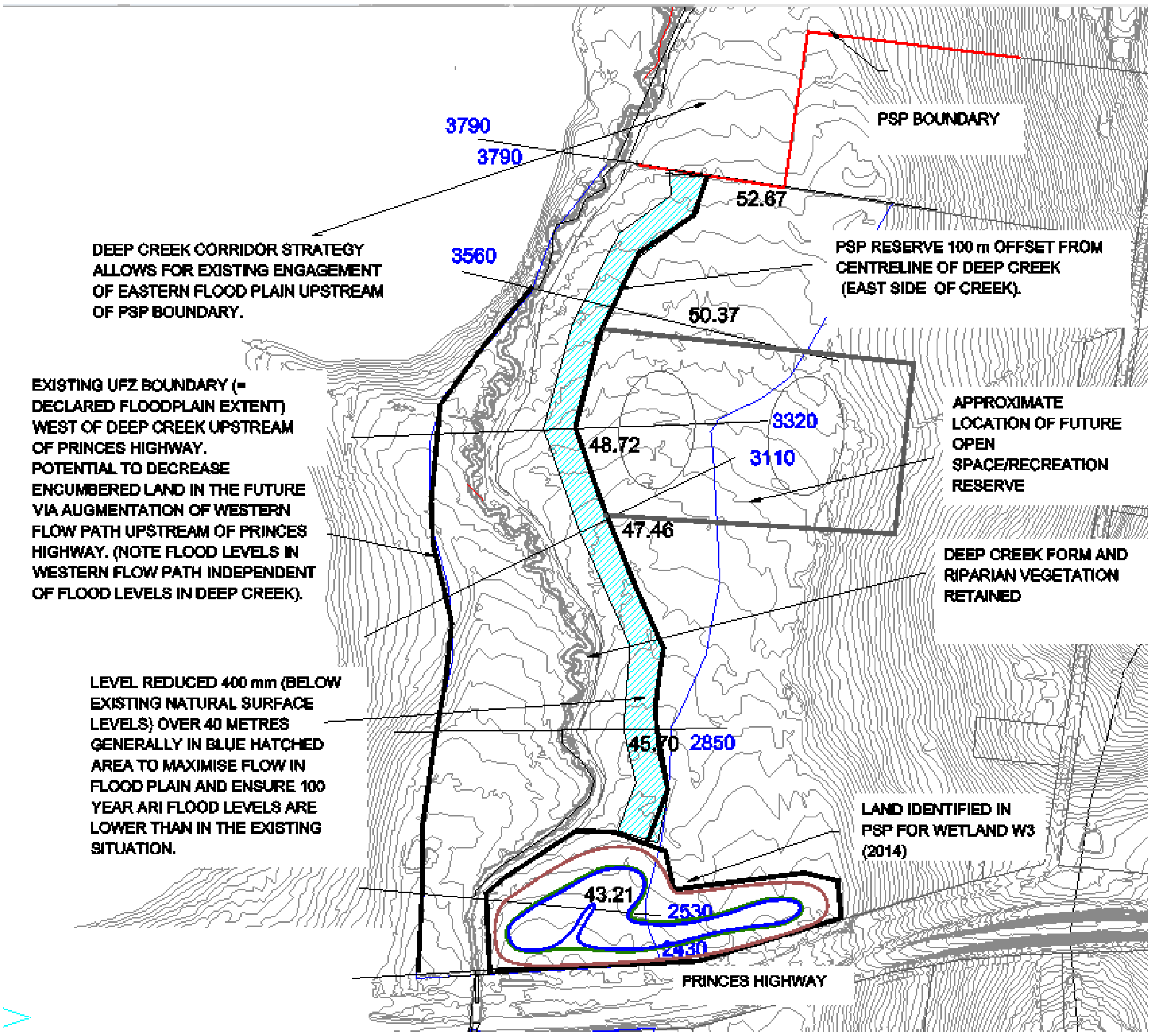


Figure 9 **Possible Deep Creek Corridor Works – Upstream of Princes Highway**

Blue text – Hec Ras Chainage

6. Hec Ras Modelling - Incorporating Deep Creek Corridor Works

6.1 Deep Creek Retarding Basin to Ryan Road

The Hec Ras model described in Section 4.1 was modified to include the on line pond as detailed in Figure 7 above. All other model aspects of the "existing" situation remained the same. Table 7 compares the "existing situation" against the situation incorporating possible future Deep Creek Corridor works.

Table 7 Hec Ras Results - With and without Deep Creek Corridor Works

Chainage (m)	Assumed 100 year Flow	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
1285	43	34.04	33.82	-0.22
1240	43	33.83	33.69	-0.14
1150	43	33.19	33.18	-0.01
1045	43	32.28	32.28	0
965	43	31.67	31.67	0
835	43	30.69	30.69	0
740	43	29.73	29.73	0
645	43	28.61	28.61	0
545	43	27.51	27.51	0
445	43	26.59	26.59	0
345	43	25.64	25.64	0
245	43	24.64	24.64	0
125	43	23.59	23.59	0
0	43	23.2	23.2	0

As detailed, the proposed works should result in a slight decrease in design flood levels downstream of Deep Creek. However, the works are also required to ensure the culvert augmentation detailed in Section 6.2 can occur with the desired outfall invert levels.

The results indicate that the expected 100 Year ARI flood levels are generally at or below the declared flood plain levels.

6.2 Upgraded Ryan Road Culvert System

It is proposed to upgrade the Ryan Road culvert system to the size, amount, minimum road level and invert levels detailed in appendix D and Figure 7 above. This is considered a prudent proposal to ensure:

- No increase in upstream 100 year flood levels, and

- 100 Year ARI protection for the Ryan Road carriageway (to new minimum road levels) given the increased population in the area using the road in the future.

6.3 Ryan Road to Princes Highway

The Hec Ras model described in Section 4.3 was modified to include:

- An assumed constriction of all flows to the reserve boundaries as detailed in Figure 8 above, and
- The flood plain augmentation works as detailed in figure 8 above.

Note this is a conservative analysis as the assumed reserve line west of Deep Creek may not incorporate fill if the low density use of this land does not change in the future.

Table 8 compares the “existing situation” against the situation incorporating possible future Deep Creek Corridor works.

Table 8 Hec Ras Results - With and without Deep Creek Corridor Works

Chainage (m)	100 year Flow	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
2330	41	41.74	41.73	-0.01
2200	41	40.71	40.78	0.07
2055	41	39.18	39.07	-0.11
1990	41	38.67	38.56	-0.11
1860	41	37.37	37.38	0.01
1780	41	36.68	36.64	-0.04
1695	41	36.08	36.04	-0.04
1655	41	35.83	35.76	-0.07
1435	41	34.74	34.68	-0.06
1385	41	34.51	34.54	0.03
1325	41	34.25	34.25	0

As detailed, the proposed works should result in a slight decrease in design flood levels in this section of waterway.

The 100 Year ARI flow will be contained to the reserve and directed west to the Deep Creek Retarding Basin. However, the updated PSP plan should allow for an overland flow path provision (e.g. road reserve or equivalent) to account for flows in excess of the 100 year flow possibly breaking away to the south upstream of Ryan Road.

6.4 Existing Princes Highway Culvert System

The flood levels directly downstream of Princes Highway do not change in the future situation. As such, the Princes Highway Culvert system is not required to be upgraded in the future.

6.5 Upstream of Princes Highway

The Hec Ras model described in Section 6.5 was modified to include:

- An assumed constriction of all flows to the reserve boundaries as detailed in Figure 9 above, and
- The eastern flood plain augmentation works as detailed in Figure 9 above.

It should be noted that this only required changing the Eastern Hec Ras model, as the PSP will have no impact in flood levels expected in Deep Creek itself or the western flood plain.

Table 9 compares the "existing situation" against the situation incorporating possible future Deep Creek Corridor works.

Table 9 Hec Ras Results - With and without Deep Creek Corridor Works Eastern flood Plain

Chainage (m)	100 year Flow in East Flood Plain	Existing 100 Year Level	100 Year Level incorporating Deep Creek Corridor works	100 Year ARI Flood Level Incorporating Deep Creek Corridor Works minus Existing 100 Yr Level (mm)
	(m3/s)	(m AHD)	(m AHD)	
3790	17.7	52.67	52.64	-0.03
3560	19.2	50.37	50.73	0.36
3320	21.1	48.72	49.31	0.59
3110	21.1	47.46	47.26	-0.2
2850	24.1	45.7	45.61	-0.09
2530	24.1	43.21	43.12	-0.09
2430	24.1	42.35	42.35	0

As detailed, the proposed works generally result in a slight decrease in design flood levels in this section of waterway. The modelling suggest that there may be a rise in flood levels at Chainage 3320 and 3560. However, as the three systems operate independently this does not affect flood levels to the west of the creek (i.e. any existing subdivisions). In addition, the proposed open space reserve (PSP plan) could be shaped to allow its western portion to be flood prone, thus reducing flood levels to closer to existing levels. Whatever the case, the only implication is on PSP land and, worse case, this results in more fill required in this area.

7. Conclusions and Further Work Required

The above work concludes that the PSP reserve areas adjacent to Deep Creek are adequate to address the MWC concerns highlighted in Section 1 above.

Further work required going forward in the design process includes, but is not limited to:

- Ensuring the design of any future subdivision relies on detailed flood plain survey information, and updated flood levels at this time to set adequate fill levels adjacent to the reserve and ensure the design of future reserve augmentation works meets the intent of the design as detailed in this report,
- Update the PSP plan to allow for an overland flow path provision (e.g. road reserve or equivalent) to account for flows in excess of the 100 year flow possibly breaking away to the south upstream of Ryan Road (although the Deep Creek corridor will have a 100 Year Capacity),
- Confirming that the ecological and cultural heritage constraints and opportunities have been fully captured by the proposals,
- Liaising with downstream affected landowners,

It is requested that MWC agree in principle to the PSP Deep Creek Reserve line given the result presented in this report.

APPENDIX A RORB Model Control Vector

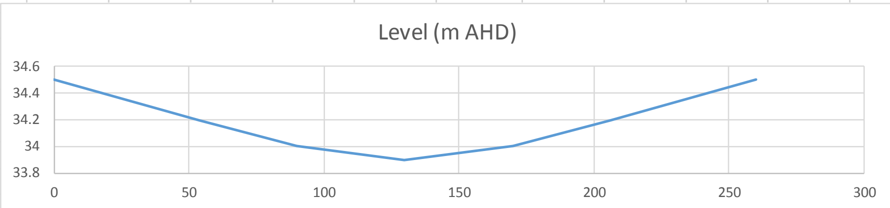
```
C DEEP CREEK TO UPSTREAM OF PAKENHAM CREEK
C STORMY WATER SOLUTIONS
C SEPTEMBER 2014
C EXISTING CATCHMENT WITH ALLOWANCE
C FOR DEVELOPMENT DSOUTH OF ELEC EASEMENT
C CONSERVATIVLY NO RB'S
C
C  DEEP_2014_oct 2014.CAT
C
0
1,1,1.9,-99,          A
3
1,1,1.1,-99,          B
4
5,1,0.7,-99
3
1,1,0.7,-99,          C
4
5,1,1.5,-99,
3
1,1,0.7,-99,          D
4
5,1,0.5,-99,
3
1,1,1.3,-99,          E
4
5,1,0.7,-99,
2,1,1,-99, F
7
End 10
3
1,2,1.3,2,-99,        G
4
7
upstream end 12
5,2,1.2,1.5,-99,
3
1,2,0.75,0.3,-99,     H
4
7
upstream end 14
5,2,0.4,1.3,-99,
3
1,2,1,0.3,-99,        I
4
7
DEEP CK AT PRINCES HWY
5,1,0.5,-99,
2,2,1,2,-99,          J
7
RYANS ROAD
2,2,0.8,2,-99,
7
DEEP CK UPSTREAM OF PAKENHAM CK
0
1.24,2.83,1.26,1.26,1.52,1.91,1.45,1.44,1.28,0.37,1.35,-99,
1,0.05,0.05,0.05,0.05,0.05,0.2,0.1,0.6,0.6,0.3,0.1,-99,
```

APPENDIX B - Ryan Road Culvert Analysis (Existing Conditions)

B.1 Design Flow = 43 m^3/s

Ryan Road culverts			
TWL =	33.85	m AHD	
Downstream IL =	32.5	m AHD	
Downstream obvert level =		33.425	m AHD
Must be outlet control - downstream end drowned			
head loss = $(Ke+Kex)\times V^2/2g + S_f \times L$			
$S_f = Q^2n^2/A^2R^{4/3}$			
culvert flowing full			
W =	1.825		
D =	0.925	m	
Design flow =	3.74	m^3/s	
Wetted perimeter =	5.50	m	
Area =	1.69	m^2	
Hyd radius =	0.306932	m	
V =	2.22	m/s	
Ke =	0.5		
Kex =	1		
n =	0.013		
L=	5		
S_f =	0.0040		
Head loss =	0.40	m	
HWL =	**34.25**	m AHD	
Total flow in four culverts =		14.96	m^3/s

Deep Creek - Ryan Road weir flow						
Weir Cross Section						
Chainage (m)	Level (m AHD)					
0	34.5					
54	34.2					
90	34					
130	33.9					
170	34					
206	34.2					
260	34.5					



Kw =	1.65		HWL =	**34.25**	m AHD	
Water Level =						
Chainage (m)	Level (m AHD)	Average Level (m)	Length (m)	H (m)	Weir flow in segment (m^3/s)	
0	34.5					
54	34.2	34.35	54	-0.1	0.0	
90	34	34.1	36	0.15	3.5	
130	33.9	33.95	40	0.3	10.8	
170	34	33.95	40	0.3	10.8	
206	34.2	34.1	36	0.15	3.5	
260	34.5	34.35	54	-0.1	0.0	
				Total Weir Flow =	28.6	m^3/s
				total flow over road and in culverts =	43.6	m^3/s

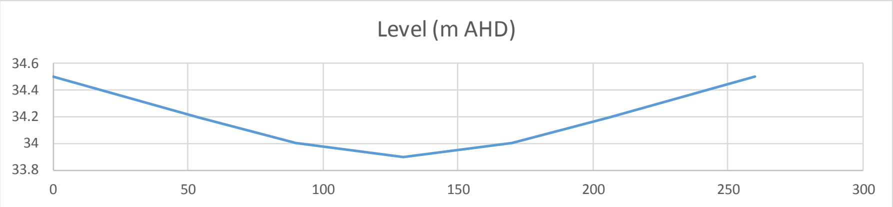
B.2 Design Flow = 18 m^3/s

Ryan Road culverts			
TWL =	33.85	m AHD	
Downstream IL =	32.5	m AHD	
Downstream obvert level =		33.425	m AHD
Must be outlet control - downstream end drowned			
head loss = $(Ke+Kex)\times V^2/2g + S_f \times L$			
$S_f = Q^2n^2/A^2R^{4/3}$			
culvert flowing full			
W =	1.825		
D =	0.925	m	
Design flow =	2.9	m^3/s	
Wetted perimeter =	5.50	m	
Area =	1.69	m^2	
Hyd radius =	0.306932	m	
V =	1.72	m/s	
Ke =	0.5		
Kex =	1		
n =	0.013		
L=	5		
S_f =	0.0024		
Head loss =	0.24	m	
HWL =	**34.09**	m AHD	
Total flow in four culverts =		11.6	m^3/s

Deep Creek - Ryan Road weir flow

Weir Cross Section

Chainage (m)	Level (m AHD)
0	34.5
54	34.2
90	34
130	33.9
170	34
206	34.2
260	34.5



Kw =	1.65	HWL =	**34.09**	m AHD
Water Level =				

Chainage (m)	Level (m AHD)	Average Level (m)	Length (m)	H (m)	Weir flow in segment (m^3/s)
0	34.5				
54	34.2	34.35	54	-0.26	0.0
90	34	34.1	36	-0.01	0.0
130	33.9	33.95	40	0.14	3.5
170	34	33.95	40	0.14	3.5
206	34.2	34.1	36	-0.01	0.0
260	34.5	34.35	54	-0.26	0.0
				Total Weir Flow =	6.9 m^3/s
				total flow over road and in culverts =	18.5 m^3/s

APPENDIX C – Princes Highway Culvert Analysis (Existing Conditions)

Deep Creek at Princes Highway				
Based on Vic Roads Drawings				
Assume all culverts flowing under outlet control				
Melbourne Bound carriageway culvert system				
Width =		3.7	m	
Depth =		3.7	m	
Number of culverts =		2		
Culvert Length =		18.3	m	
Upstream IL =		38.7	m AHD	
Upstream obvert level =		42.4	m AHD	
Downstream IL =		38.65	m AHD	
Downstream obvert level =		42.35	m AHD	
Upstream headwall =		43.3	m AHD	
100 Year Flood Level Downstream =			41.9	m AHD
Note : conservative, assumes tailwater level dominated by water level in Deep Creek Channel				
Culverts not operating under pressure - as confirmed by Vic Roads design drawings				
Water Depth in culvert =		3.4	m	
Culvert Base width		3.7	m	Culvert slope = 0.001,
Longitudinal Slope		0.00035		but backwater effects making HGL less
side slope of batters		1 in	0.01	
Flow Area (A)		12.6956	m^2	
ss length		3.40	m	
Wetted Perimeter (P)		10.50	m	
Hydraulic Radius (R)		1.21	m	
mannings n		0.013		
Capacity (Q)		41.5	m^3/s - twin culverts - Ok approx 40.7 m3/s)	
Velocity (V)		1.63	m/s	
Exit Loss coefficient =		1		
Exist loss = $K_{ex}V^2/2g$ =		0.14	m	
Depth in culvert = TWL + existing gloss =			3.39	OK, matches above
Inlet Loss coefficient =		0.5		
Inlet loss = $K_eV^2/2g$ =		0.07	m	
HWL =	42.15	.= tail water level of Warrigal bound culvert		

Warrigal Bound carriageway culvert system					
Width =		3.7	m		
Depth =		3.7	m		
Number of culverts =		2			
Culvert Length =		13.1	m		
Upstream IL =		38.8	m AHD		
Upstream obvert level =		42.5	m AHD		
Downstream IL =		38.8	m AHD		
Downstream obvert level =		42.5	m AHD		
Upstream headwall =		43.15	m AHD		
100 Year Flood Level Downstream =			42.15	m AHD	
Culverts not operating under pressure - as confirmed by Vic Roads design drawings					
Water Depth in culvert =		3.45	m		
Culvert Base width		3.7	m	Culvert slope = 0.001,	
Longitudinal Slope		0.00033		but backwater effects making HGL less	
side slope of batters		1 in	0.01		
Flow Area (A)		12.884025	m^2		
ss length		3.45	m		
Wetted Perimeter (P)		10.60	m		
Hydraulic Radius (R)		1.22	m		
mannings n		0.013			
Capacity (Q)		41.0	m^3/s - twin culverts - Ok approx 40.7 m3/s)		
Velocity (V)		1.59	m/s		
Exit Loss coefficient =		1			
Exist loss = $K_{ex}V^2/2g$ =		0.13	m		
Depth in culvert = TWL + existing gloss =			3.48		OK, matches above
Inlet Loss coefficient =		0.5			
Inlet loss = $K_eV^2/2g$ =		0.06	m		
HWL =	42.35	.= tail water level of Warrigal bound culvert			
		Confirmed , culverts not running under pressure.			

APPENDIX D - Ryan Road Culvert Analysis (Future Conditions)

Width =		1.8	m			
Depth =		1.8	m			
Number of culverts =		5				
Culvert Length =		25	m			
Upstream IL =		32.05	m AHD			
Upstream obvert level =		33.85	m AHD			
Downstream IL =		32	m AHD			
Downstream obvert level =		33.8	m AHD			
Proposed minimum Road Level =		34.4	m AHD	Raising Road 500 mm		
Existing 100 Year ARI flood level upstream =			34.25	m AHD		
100 Year Flood Level Downstream =			33.8	m AHD		
		With Downstream wetland works				
		To be confirmed at detailed design stage				
Design Flow =		40.4	m^3/s (RORB)			
Maximum Head Loss =		0.45	m			
head loss = $(Ke+Kex)\times V^2/2g+ S_f\times L$						
$S_f = Q^2n^2/A^2R^{4/3}$						
culvert flowing full						
W =		1.83	m (actual size)			
D =		1.85	m (actual size)			
Design flow =		8.08	m^3/s	5 culverts		
Wetted perimeter =		7.36	m			
Area =		3.38	m^2			
Hyd radius =		0.459860016	m			
V =		2.39	m/s			
Ke =		0.5				
Kex =		1				
n =		0.013				
L=		10				
S_f =		0.0027				
Head loss =		0.46	m	OK		