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**ARMSTRONG CREEK
URBAN GROWTH AREA**

HORSESHOE BEND PRECINCT (HBP)

**STORMWATER MANAGEMENT
STRATEGY (SWMS)**

SPARROWVALE WETLAND OPTION

DISCUSSION PAPER 3

(VERSION 1)

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1. INTRODUCTION

This discussion paper has been prepared as a follow-up to the first two papers on the Horseshoe Bend Precinct Stormwater Management Strategy (SWMS) dated 31 October 2011 and 12 February 2012 and should be read in conjunction with those documents.

This paper:

- adopts inclusion of the wetland area in Sparrowvale Farm as part of the overall Armstrong Creek Growth Area stormwater management system;
- incorporates the impacts of the proposed MAC railway corridor excavation and current preliminary design proposals for the Ring Road 4D corridor;
- incorporates diversion of the Reserve Road subcatchment in the HBP into the Sparrowvale catchment;
- provides a confirmed functional design of the overall stormwater system through application of the RORB¹ hydrologic model and MUSIC² water quality model.

The reader is referred to the prior reports for discussions of existing Barwon River flooding conditions, the environmental factors affecting Hospital Swamps, and the stormwater management requirements for HBP with and without the Sparrowvale wetlands.

2. EXISTING AND PROPOSED SUBCATCHMENTS

2.1 Existing Natural Drainage Catchments

Figure 1 shows the HBP subcatchment boundaries and primary drainage lines. The subcatchment references accord with the setup used in the RORB hydrologic model for existing catchment conditions.

¹ RORB is the name given to an industry-standard Runoff Routing Model originally due to Laurenson EM and Mein RG. It is an interactive runoff and streamflow routing program that calculates catchment losses and streamflow hydrographs resulting from rainfall events and/or other forms of inflow to channel networks. It is used for flood estimation, spillway and retarding basin design and flood routing.

² MUSIC is the acronym used for the Model for Urban Stormwater Improvement Conceptualisation software developed by the Cooperative Research Centre for Catchment Hydrology to model urban stormwater quality management schemes.

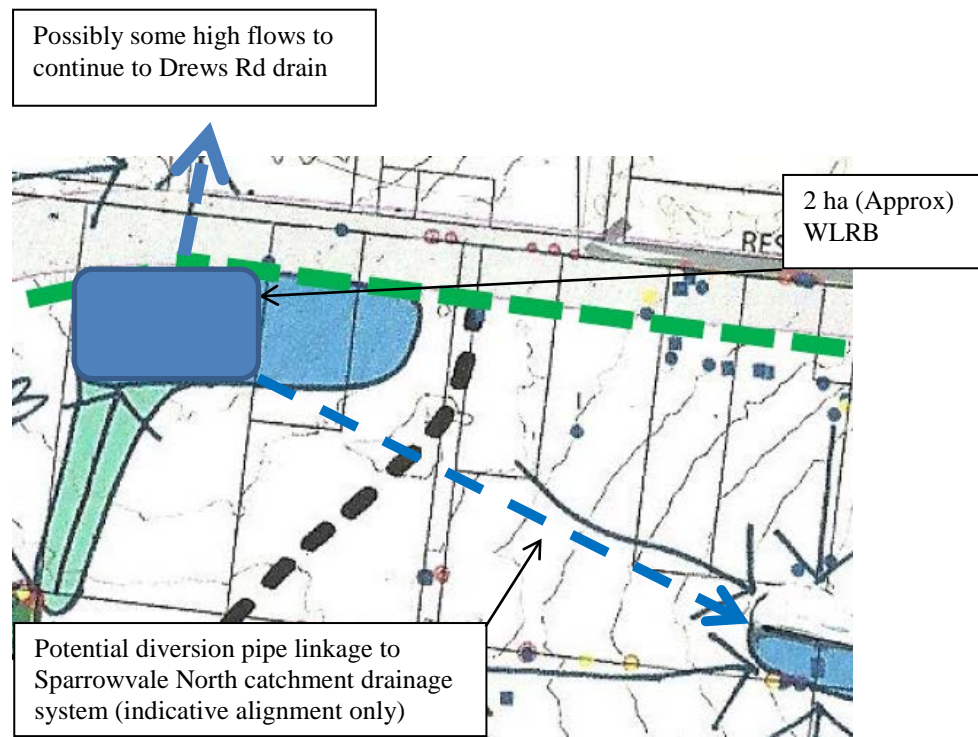
2.2 Diversion of Land Draining North into the Marshall Precinct

For the area draining northwards across Reserve Road into the Marshall Precinct no changes accrue as a direct consequence of the inclusion of the Sparrowvale Wetland option, if existing catchment boundaries are maintained.

The second report highlighted that the Sparrowvale Wetland option does present an opportunity for improved management of drainage within the Marshall Precinct, through partial or complete diversion of drainage flows from Reserve Road eastwards into the Sparrowvale North catchment. This would mean that:

- peak discharges into the Marshall Precinct could be significantly reduced;
- the estimated landtake for a WLRB within the HBP at Reserve Road could be significantly reduced.

In the second report it was considered that major flood outflows from the HBP Reserve Rd WLRB which exceed the pipe diversion capacity might still be directed in whole or in part northwards to Drews Road drain as under existing conditions. The extract sketch below illustrates this option.



Hydrologic modelling completed in this report confirms that it is feasible to divert the 100 year ARI flow to the Sparrowvale outfall system, eliminating any need for connection of drainage across the 4D corridor.

2.3 Impact of the 4D Vertical Alignment

Preliminary design details have been provided on the vertical alignment of the 4D road (Cardno Revision P3 4 April 2012). The proposal is for the road to pass under Surf Coast Highway, return to existing surface and then dip again to pass under the future rail extension to the MAC. The road would emerge from cut before reaching the Reserve Road area, maintain a lowpoint in the longitudinal profile very close to that for existing conditions at Drews Road, and then rise to a highpoint about 1 m above natural surface around Horseshoe Bend Road then dip back to natural surface east to Barwon Heads Road. The latter will be formed as an overpass to the 4D alignment.

This design proposal is consistent with drainage planning constraints in the HBP and no special fill requirements are created in the HBP as a consequence of the 4D alignment.

2.4 Impact of the MAC Rail Corridor

The Cardno 4D preliminary design plans also consider the vertical alignment of the rail corridor extension to the MAC. The rail line maintains levels close to existing conditions where the HBP drainage line will cross parallel to the 4D alignment at Barwarre Road.

To the south the rail line is cut well below natural surface across Boundary Road and into the MAC. This severs surface drainage connectivity across the rail corridor and creates a need to divert drainage both within and around the MAC.

Whilst it may be possible for pipe drainage lines to pass over the rail cut, this is not considered desirable. Instead pipe drainage for land upslope of the rail corridor would best be piped either north or south to avoid the need for crossings.

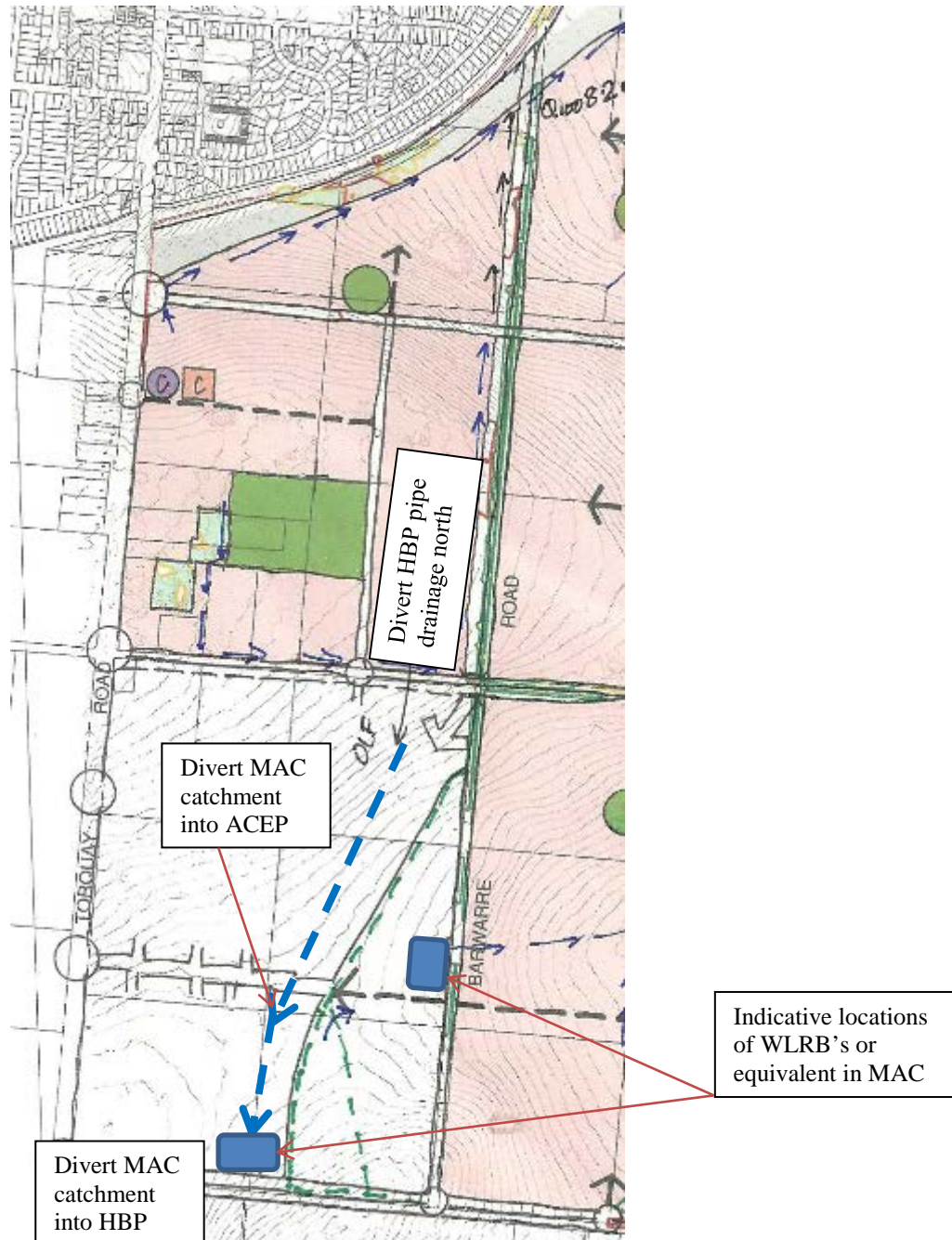
Within the HBP on Boundary Road west of the rail corridor along the northern frontage of the MAC, it is feasible to divert pipe drainage northwards into the Reserve Road catchment, without the need for any special storages or treatment on Boundary Road.

The alternative to this diversion is to provide a suitable WLRB on Boundary Road and pipe south into the MAC at existing rural discharge rates. It is assumed that this option will not be attractive from a development yield or asset management viewpoint so the northern diversion option has been adopted.

Within the MAC itself the rail corridor cut requires diversion of drainage for lands to the west which naturally drain eastwards into the Sparrowvale catchment. The diversion must be to the south into the Armstrong Creek (ACEP) catchment.

A small area on the east side of the rail corridor in the south part of the MAC which drains naturally south into the ACEP must be diverted east into the HBP for similar reasons.

The following sketch illustrates the proposed adjustments to drainage patterns in and around the MAC and rail corridor.



2.5 Proposed SWMS Subcatchments

Figure 2 shows the adopted subcatchment boundaries and main piped and open waterway drainage lines in the HBP, with the various drainage diversions in place. Adjustments to the subcatchment structure have been made in the RORB hydrologic model to account for these changes.

3. STORMWATER MODELLING

3.1 Peak Flows-Existing Conditions

3.1.1 Model Parameter Values

A RORB hydrologic model was prepared for existing catchment conditions as shown diagrammatically on Figure 1.

The model was run with Geelong Airport rainfall data, the “filtered” pattern option selected, with areal reduction factors as by Siriwardena and Weinmann, and using the following storage and rainfall model parameter values:

Storage Model: $K_c=3.60$, $m=0.80$,
Rainfall Loss Model: as per Table 1.

TABLE 1 Rainfall Loss Model Parameters for RORB		
ARI (years)	Initial Loss (mm)	Pervious Area Runoff Coefficients
1	20	0.56
2	20	0.56
5	20	0.59
10	20	0.63
20	20	0.67
50	20	0.73
100	20	0.79

(Note: The ratio K_c/D_{av} obtained by the CCMA for modelling of Armstrong Creek catchment was used to estimate the new catchment K_c value for HBP (T Jones pers. comm.).)

This ensures the relative storage for each reach in HBP remains the same as that used in the wider Armstrong Creek catchment. (D_{av} = Average flow length for all sub areas with respect to the model outlet).

For Armstrong Creek $K_c/D_{av} = 14.0/6.50 = 2.154$.

*D_{av} for the HBP existing conditions structure shown on Figure 1 is 1.66 (generated by the model). Hence $K_c = 2.154 * 1.66 = 3.6$ with $m=0.8$.)*

3.1.2 RORB Model Results

Model results are summarised in Table 2.

TABLE 2 RORB Model Results (Model: HBP Exist.cat)							
Location	ARI (yrs)	Peak Discharge (m3/s)	Critical Duration (hrs)	Location	ARI (yrs)	Peak Discharge (m3/s)	Critical Duration (hrs)
Horseshoe Bend Road South	1	0.8	30	Horseshoe Bend Road North	1	0.2	30
	2	1.0	30		2	0.3	12
	5	1.5	48		5	0.5	12
	10	2.0	9		10	0.6	9
	20	2.8	9		20	0.9	9
	50	3.9	9		50	1.2	9
	100	5.1	9		100	1.5	9
Batten Road	1	1.0	30	Barwon Heads Road North	1	0.8	30
	2	1.3	48		2	0.9	12
	5	2.0	36		5	1.4	12
	10	2.4	12		10	1.9	12
	20	3.3	9		20	2.5	9
	50	4.7	9		50	3.2	9
	100	6.1	9		100	4.7	9
Barwon Heads Road South	1	1.0	30	Sparrowvale North catchment at Sparrowvale Road	1	0.9	30
	2	1.4	48		2	1.1	12
	5	2.1	36		5	1.7	12
	10	2.5	12		10	2.2	9
	20	3.4	12		20	3.1	9
	50	4.9	12		50	4.2	9
	100	6.3	12		100	5.5	9
Sparrowvale South catchment at Charlemont Road	1	1.0	30	Reserve Road catchment at Barwarre Road	1	0.2	30
	2	1.4	48		2	0.3	12
	5	2.2	36		5	0.4	12
	10	2.6	24		10	0.6	9
	20	3.6	12		20	0.8	9
	50	5.2	12		50	1.2	9
	100	6.7	12		100	1.5	9
				Reserve Road catchment outfall at Reserve Road/Drews Road	1	0.5	30
					2	0.6	48
					5	0.9	12
					10	1.1	9
					20	1.5	9
					50	2.2	9
					100	2.9	9

3.2 Peak Flows and levels-Fully Developed Conditions

3.2.1 Parameter Adjustments

The RORB hydrologic model was adjusted to suit proposed future developed catchment conditions and drainage diversions, as shown diagrammatically on Figure 2.

The K_c value was again adjusted to suit the amended structure and additional subareas east of Barwon Heads Road. D_{av} for the setup shown on Figure is 2.16, so $K_c=2.154*2.16 = 4.70$, with $m=0.8$. Rainfall parameters are unchanged.

Percentage imperviousness for each subarea was set according to the current proposed masterplan layout:

- 60% impervious for conventional residential development;
- 70% impervious for schools;
- 80% impervious for medium density areas;
- 90% impervious for the MAC;
- 65% impervious for residential areas abutting the MAC.

Model results are summarised in Table 3.

3.2.2 Flood Storage Data

In addition to the subarea and reach data in Table 1, the stage-storage characteristics of the four major proposed stormwater management assets were also input to the model.

These assets are first and foremost sized to ensure sediment management across the HBP is adequate for the purposes of protection of proposed open waterways within the HBP. A minimum treatment performance standard of 70% removal of Total Suspended Solids (TSS) is arbitrarily set in the MUSIC model to determine the minimum water surface area required for each asset to comply with this target.

The two storages designed as linear waterbodies to overcome flat drainage gradient issues at the two main sewer crossings have larger water surface areas than required to achieve the 70% TSS removal criteria. These water surface areas are determined by length of the storage and average water surface width of 20 m.

Table 3 summarises the stage-area-storage relations and the hydraulic controls adopted for each asset after trial and error modelling in RORB and MUSIC. The Normal Top Water Levels (NTWL's) have been determined using the 0.5 m contour data plus as-built levels along the Barwon Water main sewer.

Note: Detail design of each asset may result in adjustments to the NTWL's. The current proposal for the Sparrowvale North (sewer crossing) SBRB provides for a 1m clearance between NTWL and the top of the sewer. As this selection has great significance for fill volumes across the surrounding lands, it is expected that detail design will endeavour to reduce the clearance and lower the whole stage-storage relation accordingly.

Storage	NTWL (m)	Stage (m)	Area (m²)	Storage (m³)	Outlet Controls
Horseshoe Bend Road South SBRB (1.0 ha reserve)	16.00	16.00	5,000	0	0.3 weir
		16.50	5,460	2,615	2.0 m weir
		17.00	7,475	5,849	
		18.00	9,780	14,477	20 m overflow weir
Barwon Heads Road South SBRB (2.25 ha reserve)	4.00	4.00	8,500	0	0.5 m weir
		4.50	9,600	4,525	2.5 m weir
		5.00	15,395	10,775	
		6.00	20,350	28,650	20 m overflow weir
Reserve Road SBRB (1.6 ha reserve)		6.50	22,500	39,360	
	8.50	8.50	5,500	0	0.3 m weir
		9.00	6,244	2,936	0.6 m weir
		9.50	9,320	6,827	
Sparrowvale North (sewer crossing) SBRB (2.25 ha reserve)		10.50	12,740	17,857	
		11.00	16,000	25,040	20 m overflow weir
	6.75	6.75	10,250	0	0.5 m weir
		7.25	11,564	5,453	5.3 m weir
		7.75	17,000	12,595	
		8.25	19,865	21,810	20 m overflow weir
		8.75	22,725	32,458	

3.2.3 RORB Model Results

The RORB model results are summarised in Table 4.

ARI (years)	Location	Peak Inflow (m³/s)	Peak Outflow (m³/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m³)
1	Horseshoe Bend Rd South SBRB	3.1	1.8	9	17.02	6,060
	Batten Rd		2.6	9		
	Barwon Heads Road South SBRB	3.1	2.4	9	5.01	11,000
	Charlemont Road Outfall		2.6	9		
	Boundary Rd diversion	1.3	1.3 (north) 0 (to MAC)	25 m		
	Barwarre Road at 4D/Rail		1.8	25 m		
	Reserve Road SBRB	2.9	1.3	9	9.69	8,930

TABLE 4 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)						
ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
	Horseshoe Bend Road North		1.6	9		
	Sparrowvale North (Sewer crossing) SBRB	4.5	2.6	9	7.60	10,500
	Sparrowvale Road Outfall		2.8	9		
	Combined Outfall to Sparrowvale Farm		5.6	9		
2	Horseshoe Bend Rd South SBRB	3.7	2.3	9	17.12	6,870
	Batten Rd		3.5	9		
	Barwon Heads Road South SBRB	4.0	3.3	9	5.15	13,400
	Charlemont Road Outfall		3.4	9		
	Boundary Rd diversion	1.6	1.6 (north) 0 (to MAC)	15 m		
	Barwarre Road at 4D/Rail		2.1	25 m		
	Reserve Road SBRB	3.5	1.7	9	9.88	11,100
	Horseshoe Bend Road North		2.2	9		
	Sparrowvale North (Sewer crossing) SBRB	5.5	3.7	9	7.72	12,100
	Sparrowvale Road Outfall		4.1	9		
Combined Outfall to Sparrowvale Farm		7.7	9			
5	Horseshoe Bend Rd South SBRB	5.3	2.9	9	17.25	8,000
	Batten Rd		4.7	9		
	Barwon Heads Road South SBRB	5.4	4.4	9	5.32	16,400
	Charlemont Road Outfall		4.7	9		
	Boundary Rd diversion	2.2	2.2 (north) 0 (to MAC)	15 m		
	Barwarre Road at 4D/Rail		3.3	2		
	Reserve Road SBRB	5.2	2.4	9	10.15	14,000
	Horseshoe Bend Road North		3.1	9		
	Sparrowvale North (Sewer crossing) SBRB	7.8	5.0	9	7.83	14,200
	Sparrowvale Road Outfall		5.6	9		
Combined Outfall to Sparrowvale Farm		10.8	9			
10	Horseshoe Bend Rd South SBRB	6.8	3.4	2	17.34	8,790
	Batten Rd		5.5	9		
	Barwon Heads Road South SBRB	6.3	5.2	9	5.42	18,300
	Charlemont Road Outfall		5.6	9		
	Boundary Rd diversion	3.0	3.0 (north) 0 (to	2		

TABLE 4 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)						
ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
			MAC)			
	Barwarre Road at 4D/Rail		4.2	2		
	Reserve Road SBRB	6.9	2.8	9	10.33	16,000
	Horseshoe Bend Road North		3.7	2		
	Sparrowvale North (Sewer crossing) SBRB	10.1	5.9	9	7.91	15,700
	Sparrowvale Road Outfall		6.5	9		
	Combined Outfall to Sparrowvale Farm		12.8	9		
20	Horseshoe Bend Rd South SBRB	8.7	4.6	2	17.54	10,500
	Batten Rd		6.6	9		
	Barwon Heads Road South SBRB	7.6	6.3	9	5.56	20,800
	Charlemont Road Outfall		6.8	9		
	Boundary Rd diversion	3.8	3.6 (north) 0.2 (to MAC)	2		
	Barwarre Road at 4D/Rail		5.4	2		
	Reserve Road SBRB	9.4	4.7	2	10.29	15,500
	Horseshoe Bend Road North		1.6	9		
	Sparrowvale North (Sewer crossing) SBRB	13.2	7.2	9	8.01	17,800
	Sparrowvale Road Outfall		7.9	9		
	Combined Outfall to Sparrowvale Farm		15.5	9		
50	Horseshoe Bend Rd South SBRB	11.4	6.2	2	17.79	12,600
	Batten Rd		8.4	2		
	Barwon Heads Road South SBRB	9.9	7.7	9	5.72	23,700
	Charlemont Road Outfall		8.2	9		
	Boundary Rd diversion	4.7	3.6 (north) 1.1 (to MAC)	2		
	Barwarre Road at 4D/Rail		6.9	2		
	Reserve Road SBRB	12.3	4.6	9	10.76	21,500
	Horseshoe Bend Road North		6.0	1.5		
	Sparrowvale North (Sewer crossing) SBRB	17.1	8.8	9	8.12	19,900
	Sparrowvale Road Outfall		9.7	9		
	Combined Outfall to Sparrowvale Farm		18.9	9		
100	Horseshoe Bend Rd South SBRB	14.0	7.9	1	18.01	7.9
	Batten Rd		10.6	2		
	Barwon Heads Road South	12.4	9.2	2	5.89	26,600

TABLE 4 RORB Model Results for fully developed conditions (Model: HBP Developed Final.cat)						
ARI (years)	Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Critical duration (hrs)	Water Level (m)	Storage Volume (m3)
	SBRB					
	Charlemont Road Outfall		9.7	9		
	Boundary Rd diversion	5.6	3.6 (north) 2.0 (to MAC)	2		
	Barwarre Road at 4D/Rail		8.4	2		
	Reserve Road SBRB	15.0	5.5	9	10.97	24,600
	Horseshoe Bend Road North		7.2	9		
	Sparrowvale North (Sewer crossing) SBRB	21.0	10.5	9	8.22	21,900
	Sparrowvale Road Outfall		11.5	9		
	Combined Outfall to Sparrowvale Farm		22.3	9		

- The results show that:
- Peak 10 year ARI discharges in the HBP at Boundary Road/Rail Crossing are 3 m3/s and this is the minimum flow to be diverted north into the Sparrowvale North catchment.
- The full 100 year ARI discharge from the Reserve Road SBRB can be diverted southeasterly into the Sparrowvale North catchment without flood levels at the 4D boundary exceeding natural surface.
- Consequently, peak 100 year ARI discharges into the Marshall Precinct at Reserve Road are reduced by 2.9 m3/s compared with existing conditions.
- Peak 100 year ARI flows east of Horseshoe Bend Road in the Sparrowvale North waterway are 7.3 m3/s into the Sparrowvale North (Sewer Crossing) SBRB, rising to 10.5 m3/s across the sewer and Barwon Heads Road.
- Peak 100 year ARI discharges in the Sparrowvale South waterway east of Horseshoe Bend Road can be maintained between 9 and 10.6 m3/s to Charlemont Road.
- Peak 100 year ARI discharge to Sparrowvale Farm will be 22.3 m3/s for full development compared with 12.2 m3/s for existing conditions.

3.2.4 Diversion Conduits

The diversion conduit southeast from the Reserve Road SBRB to Horseshoe Bend Road and the outfall from the Sparrowvale North (Sewer Crossing) SBRB to Sparrowvale Road will be pipelines.

To confirm pipe sizing and levels hydraulic gradeline analysis was undertaken using a spreadsheet program developed by the author. Invert levels and lengths used for the analyses are preliminary estimates only and will be subject to variation to comply with servicing and development layout constraints.

The results summarised in Figure 4 confirm the following:

- The Reserve Road SBRB diversion pipeline will need to be 1800 mm diameter to the junction pit at Horseshoe Bend Road, increasing to 1950 mm diameter downstream to the next SBRB.

(Notes: These pipes will convey 100 year ARI discharges so as to eliminate the need for an additional excavated surface floodway across the subcatchment divide. However a 20 m green link doubling as a surface floodway should be retained east of Horseshoe Bend Road. Flows exceeding 100 years ARI at the Reserve Road SBRB will overflow the 4D alignment (at natural surface level) and continue northwards through to the Marshall Precinct.)

- The Sparrowvale North Outfall pipeline from the Sewer Crossing SBRB across Barwon Heads Road to Sparrowvale Road will generally be a 1500 mm diameter to convey 10 year ARI flows. Cover restrictions will likely require twin 1350 mm pipes to be provided across Sparrowvale Road to the linear wetland downstream.

(Note: Surcharge flows greater than 10 year ARI pipe capacity will be conveyed overland in grassed floodways not less than 30 m in width (including pedestrian trails. The Barwon Heads Road crossing will be duplicated or otherwise augmented with appropriate inlet/outlet structures to convey 100 year ARI flows below the road).

The Boundary Road/Rail diversion pipe will need to be not less than 1200 mm in diameter to convey the minimum 10 year ARI flow of 3 m³/s.

3.2.5 Open Waterway Reserves

The 100 year ARI peak flows in the Sparrowvale South waterway are less than 11 m³/s. With average longitudinal grade of 1 %, such flows can be easily conveyed in a naturalised open waterway within a 35 m wide reserve, including a 4 m wide pedestrian/maintenance trail.

At Charlemont Road/ Sparrowvale Road the natural surface levels prevent free-draining open waterways from being constructed. With negligible grades it is necessary to adopt a linear wetland system for the drainage lines with NTWL set at approximately 1.00 m AHD as in the East precinct. In turn this requires reserve widths to increase to not less than 50 m.

3.2.6 Other Floodways

All roads and reserves used to convey overland flows through the subdivision to and from the WLRB should also provide at least 300 mm freeboard above 100 year ARI flood levels to adjacent finished surface levels or floor levels.

3.3 Water Quality Modeling

The proposed stormwater drainage system was modeled using MUSIC Version 3 with the 6 minute rainfall data sequence for Geelong North, 1980-89 (*Filename: HBP Developed Final GN 1980-89 6 min*), and assuming:

- full development of the subject lands;
- asset sizing and characteristics as set out in Table 5;

The model structure is shown diagrammatically on Figure 5.

In addition to the four major treatment SB's upstream of the main sewer alignment, the MUSIC model includes two extra sediment storages at Sparrowvale Road and at the combined outfall downstream of the precinct boundary, to protect the receiving wetlands.

A hypothetical wetland area is added at the downstream end of the MUSIC model treatment train to quantify what additional treatment area would be required to ensure compliance with best management practice (BMP) stormwater quality treatment standards for the full precinct, should the proposal to utilise the whole Sparrowvale Farm wetlands area not materialize for some reason.

TABLE 5 Components of Stormwater Quality Treatment System, HBP				
Asset	NTWL (m)	Water Surface Area at NTWL (m ²)	Volume at NTWL (m ³)	Extended detention depth (m)
Horseshoe Bend Rd South SB	16.00	5,000	4,000	0.5
Barwon Heads Road South SBR	4.00	8,500	7,000	0.5
Reserve Road SB	8.50	5,500	4,500	0.5
Sparrowvale North (Sewer Crossing) SB	6.75	10,250	9,500	0.5
Sparrowvale Road SB	1.00	1,200	1,000	0.5
Sparrowvale Wetland Inlet SB	1.00	2,500	2,000	0.5
Sparrowvale Farm Wetland (hypothetical minimum extra wetland area needed to comply with BMP)	1.00	75,000	45,000	0.3

The results in Table 6 confirm that:

- the key sediment management criteria for protection of open waterways in the HBP will be achieved;
- in conjunction with the sediment basins, a hypothetical wetland of 7.5 ha at the outlet from the HBP to Sparrowvale Farm would suffice to ensure compliance with BMP standards for the full Precinct.

It follows from these results that with a water surface area of some 220 ha at 0.95 m:

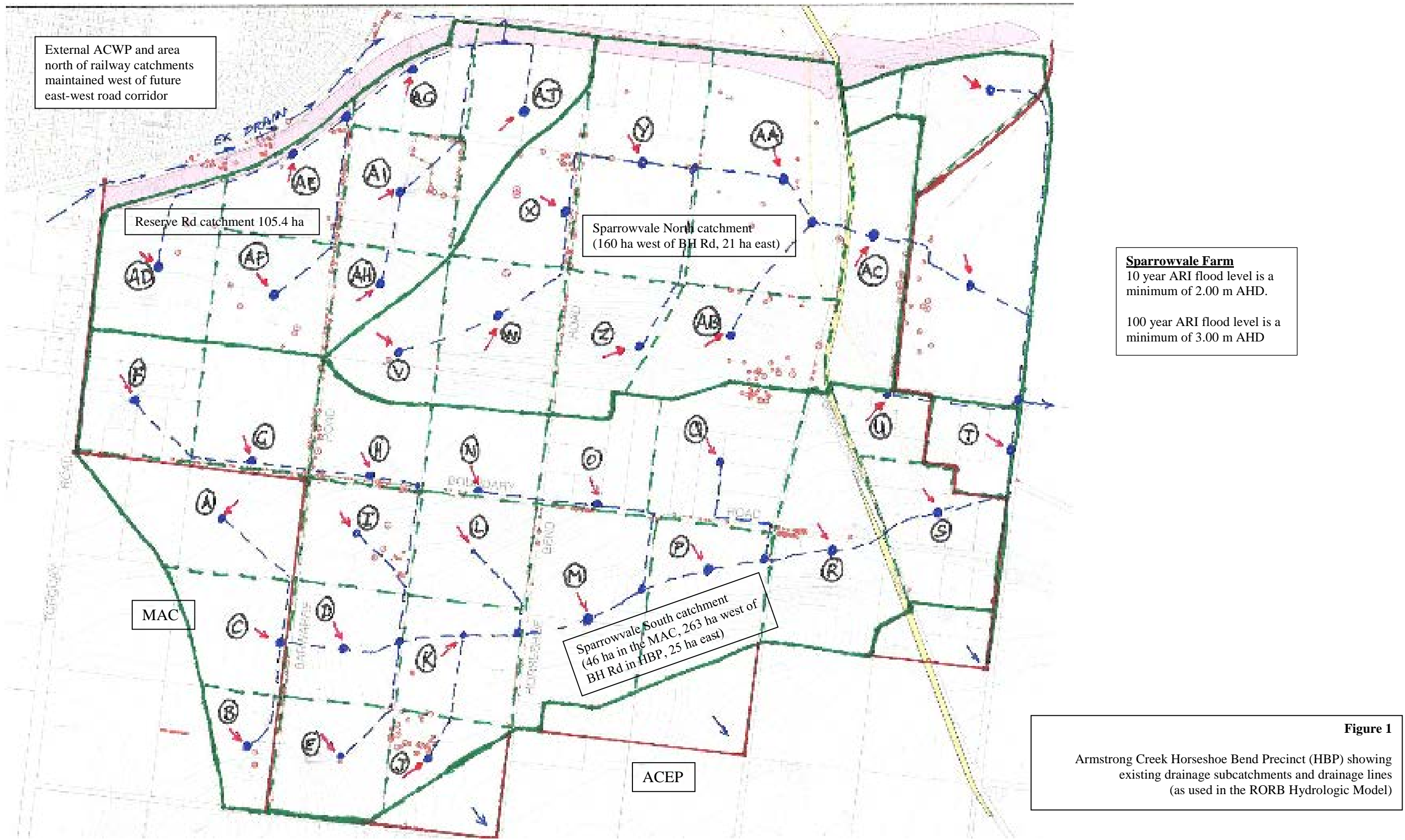
- the proposed major freshwater wetland system in Sparrowvale Farm is far larger than required to deal with stormwater management issues arising from the HBP;
- other than minor earthworks to protect identified vegetation areas in the southeast corner of the farm from prolonged inundation, and weed management, no special measures are required to manage stormwater across the farm if and when it is converted to public ownership.

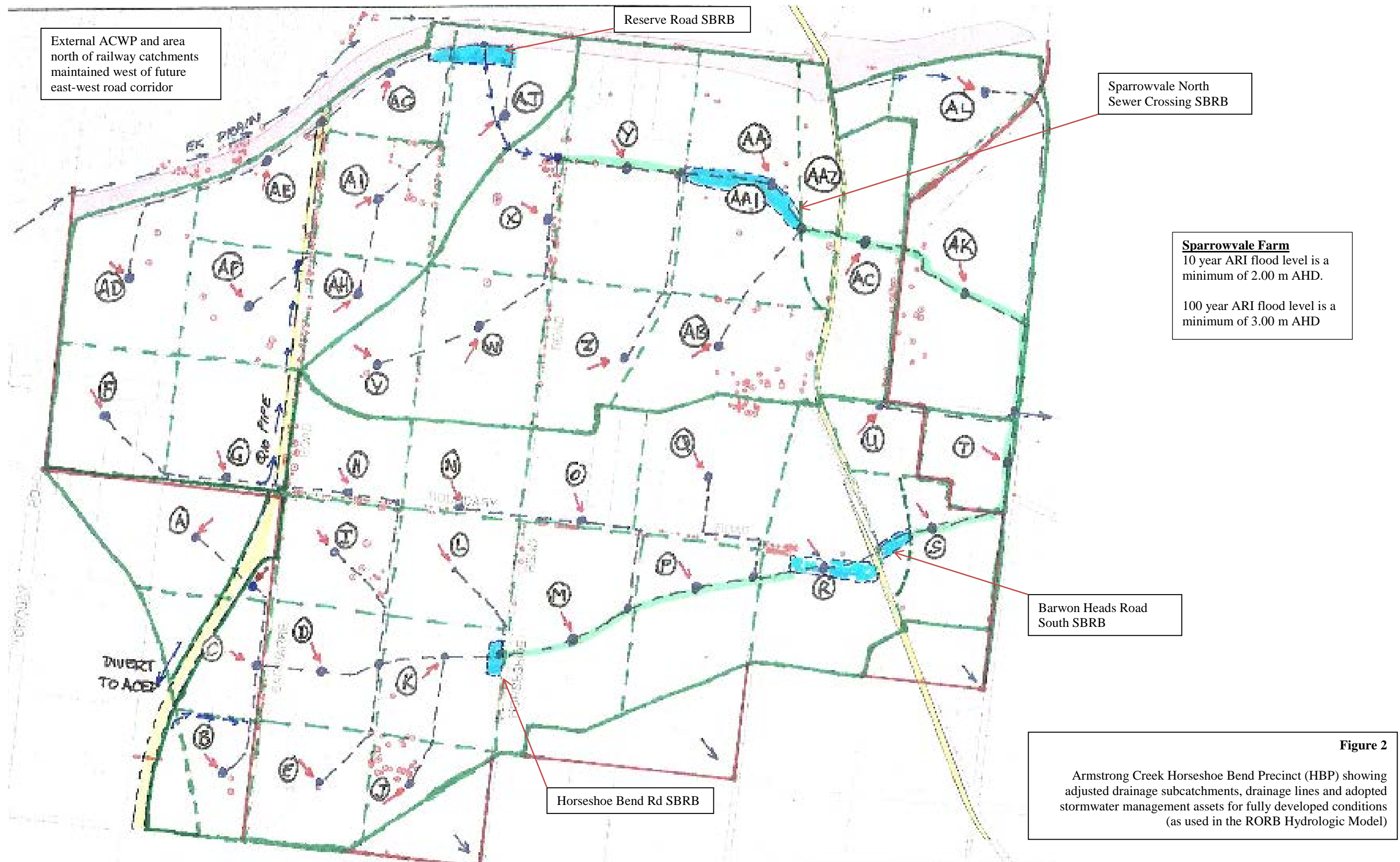
TABLE 6 MUSIC Model Results			
(Geelong North 1980-89 6 minute data sequence)			
Asset/Parameter	Input Loads	Residual Loads	% load removal
<u>Horseshoe Bend Road SB</u>			
Flow (ML/yr)	377	373	1
Suspended Solids (Kg/yr)	62,100	18,000	71
Total Phosphorus (Kg/yr)	139	69	50
Total Nitrogen (Kg/yr)	974	761	22
Gross Pollutants (kg/yr)	13,700	0	100
<u>Barwon Heads Road South SB</u>			
Flow (ML/yr)	760	753	1
Suspended Solids (Kg/yr)	92,600	32,500	65
Total Phosphorus (Kg/yr)	224	131	42
Total Nitrogen (Kg/yr)	1,860	1,530	18
Gross Pollutants (kg/yr)	16,200	0	100
<u>Reserve Road SB</u>			
Flow (ML/yr)	407	403	1
Suspended Solids (Kg/yr)	79,100	20,700	74
Total Phosphorus (Kg/yr)	164	76	54
Total Nitrogen (Kg/yr)	1,160	874	24
Gross Pollutants (kg/yr)	17,100	0	100
<u>Sparrowvale North (Sewer Crossing) SB</u>			
Flow (ML/yr)	855	847	1
Suspended Solids (Kg/yr)	107,000	35,400	67
Total Phosphorus (Kg/yr)	254	145	43
Total Nitrogen (Kg/yr)	2,170	1,740	20
Gross Pollutants (kg/yr)	18,900	0	100
<u>Sparrowvale Rd SB</u>			
Flow (ML/yr)	930	929	0
Suspended Solids (Kg/yr)	51,500	40,400	22
Total Phosphorus (Kg/yr)	178	161	9
Total Nitrogen (Kg/yr)	1,970	1,920	3
Gross Pollutants (kg/yr)	3,470	0	100
<u>Reserve Road SB</u>			
Flow (ML/yr)	407	403	1-
Suspended Solids (Kg/yr)	79,100	20,700	74
Total Phosphorus (Kg/yr)	164	76	54
Total Nitrogen (Kg/yr)	1,160	874	24
Gross Pollutants (kg/yr)	17,100	0	100
<u>Sparrowvale Wetlands SB</u>			
Flow (ML/yr)	1,870	1,870	0
Suspended Solids (Kg/yr)	105,000	82,400	21
Total Phosphorus (Kg/yr)	361	326	10
Total Nitrogen (Kg/yr)	3,960	3,840	3
Gross Pollutants (kg/yr)	5,990	0	100

TABLE 6 MUSIC Model Results
(Geelong North 1980-89 6 minute data sequence)

Asset/Parameter	Input Loads	Residual Loads	% load removal
<u>Total Assets including Sparrowvale Wetlands SB</u>	Total Source Load	Loads removed in HBP Assets	% removal of HBP source loads
Flow (ML/yr)	1,890	1,870	1
Suspended Solids (Kg/yr)	361,000	82,400	77
Total Phosphorus (Kg/yr)	752	326	57
Total Nitrogen (Kg/yr)	5,360	3,840	29
Gross Pollutants (kg/yr)	77,400	0	100
<u>Total Assets including 7.5 ha Sparrowvale Wetlands</u>	Total Source Load	Loads removed in HBP Assets	% removal of HBP source loads
Flow (ML/yr)	1,890	1,770	7
Suspended Solids (Kg/yr)	361,000	47,500	87
Total Phosphorus (Kg/yr)	752	210	72
Total Nitrogen (Kg/yr)	5,360	2,950	45
Gross Pollutants (kg/yr)	77,400	0	100

Neil M Craigie





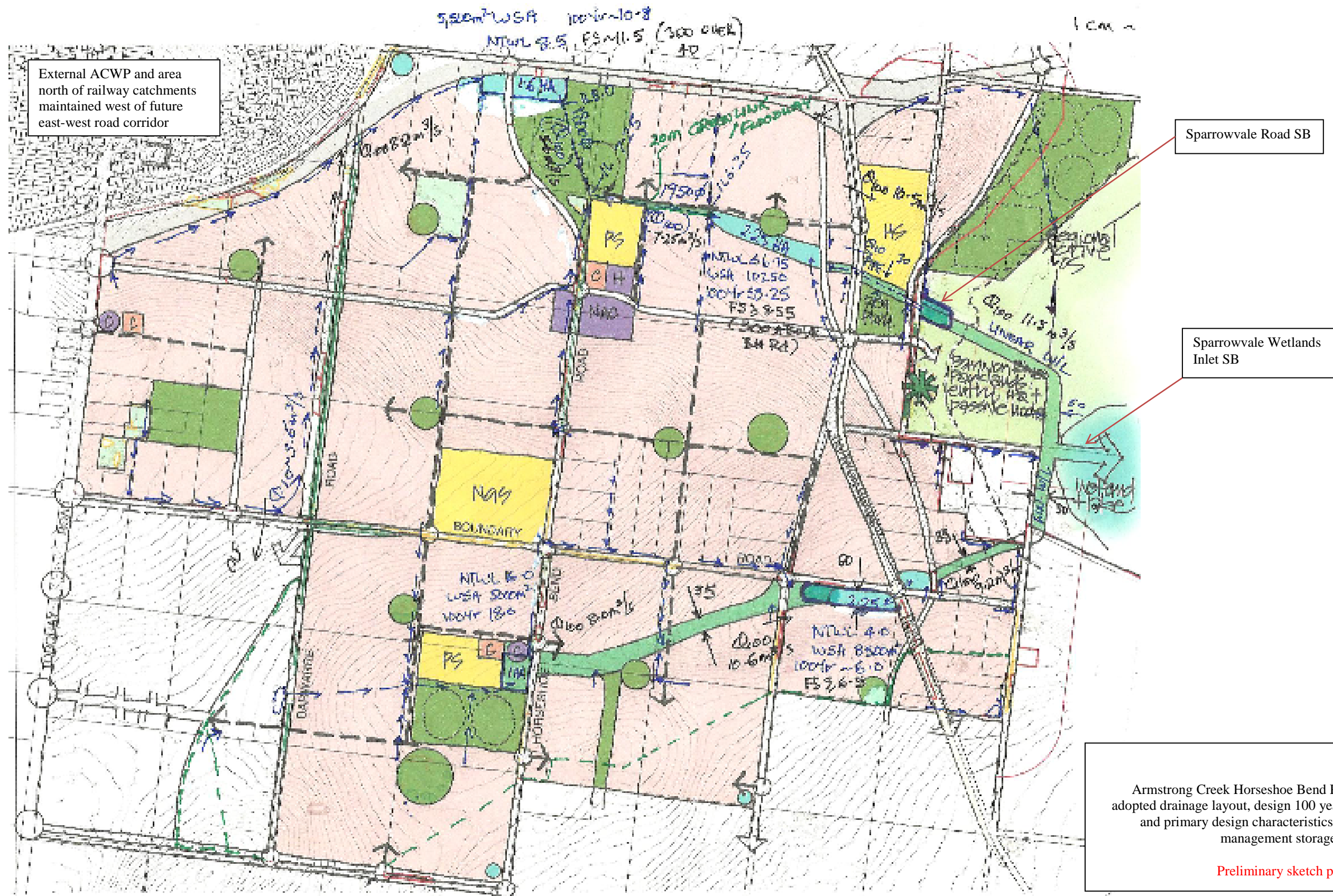


Figure 3
Armstrong Creek Horseshoe Bend Precinct (HBP) showing adopted drainage layout, design 100 year ARI peak discharges, and primary design characteristics of the main stormwater management storages and drainage reserves
Preliminary sketch plan only-to be upgraded

**HBP SWMS Sparrowvale Wetland Option
DISCUSSION PAPER 3 V1, 9 April 2012**

HYDRAULIC CHECKING SHEET

CLIENT: HBP Landowners Group
=====

PROJECT: Horseshoe Bend Rd Nth Outfall
=====

DATE: 09-Apr-12
=====

ASSUMPTIONS Pipe friction calculated using Manning's Formula with "n" = 0.013
Pit losses from Missouri Charts and Hare (1983)

Pipe Reference Nos 100 yr Starting Water Level 8.00

Downstream Pit Details			Upstream Pit Details			Pipeline Details					Downstream End		Upstream End		Pit Losses				U/S HGL	Adopted	U/S	F board		
Pit No.	Invert Level (m)	Chainage (m)	Pit No.	Invert Level (m)	Chainage (m)	Dia D (m)	Design Fbw (l/s)	Length L (m)	Full Vc (m/s)	V*V 2g (m)	HGL Level (m)	Obvert Level (m)	Pipe Fric Sbpe (m)	Pipe Fric Loss (m)	HGL Level (m)	Obvert Level (m)	D u/s D d/s	Q u/s Q d/s	Loss Coeff Ku	ku.V^2 2g (m)	U/S HGL + Pit Loss (m)	Adopted U/S Pit HGL (m)	U/S Surface Level (m)	F board at Pit (m)
1	6.25	0.00	2	7.25	410.00	1.95	7250	410.00	2.43	0.30	8.20	8.20	385	1.06	9.26	9.20	0.94	0.77	1.30	0.39	9.65	9.65	11.00	1.35
2	7.40	410.00	3	8.00	710.00	1.82	5600	300.00	2.14	0.23	9.65	9.22	452	0.66	10.32	9.82	0.00	0.00	0.70	0.16	10.48	10.48	11.00	0.52

Pit 1=inlet to Sewer Crossing SBRB, Pit 2 = junction at Horseshoe Bend Road, Pit 3 = outlet from Reserve Road SBRB

HYDRAULIC CHECKING SHEET

CLIENT: HBP Landowners Group
=====

PROJECT: Barwon Heads Rd Nth Outfall
=====

DATE: 09-Apr-12
=====

ASSUMPTIONS Pipe friction calculated using Manning's Formula with "n" = 0.013
Pit losses from Missouri Charts and Hare (1983)

Pipe Reference Nos Sewer Xing SBRB to Sparrowvale Rd SB-10 yr Starting Water Level 2.35

Downstream Pit Details			Upstream Pit Details			Pipeline Details					Downstream End		Upstream End		Pit Losses				U/S HGL	Adopted	U/S	F board		
Pit No.	Invert Level (m)	Chainage (m)	Pit No.	Invert Level (m)	Chainage (m)	Dia D (m)	Design Fbw (l/s)	Length L (m)	Full Vc (m/s)	V*V 2g (m)	HGL Level (m)	Obvert Level (m)	Pipe Fric Sbpe (m)	Pipe Fric Loss (m)	HGL Level (m)	Obvert Level (m)	D u/s D d/s	Q u/s Q d/s	Loss Coeff Ku	ku.V^2 2g (m)	U/S HGL + Pit Loss (m)	Adopted U/S Pit HGL (m)	U/S Surface Level (m)	F board at Pit (m)
1	0.10	0.00	2	0.70	20.00	1.35	3050	20.00	2.13	0.23	2.35	1.45	306	0.07	2.42	2.05	1.13	2.00	1.30	0.30	2.72	2.72	3.00	0.28
2	1.00	20.00	3	3.00	240.00	1.52	6100	220.00	3.34	0.57	2.72	2.52	146	1.50	4.22	4.52	0.94	0.97	1.30	0.74	4.96	5.27	8.00	2.73
3	3.10	240.00	4	3.50	280.00	1.43	5900	40.00	3.70	0.70	5.27	4.53	109	0.37	5.63	4.93	1.00	1.00	1.30	0.91	6.54	6.54	8.00	1.46
4	3.60	280.00	5	5.00	370.00	1.43	5900	90.00	3.70	0.70	6.54	5.03	109	0.82	7.36	6.43	0.00	0.00	0.70	0.49	7.85	7.85	8.00	0.15

Pit 1-2=twin 1350 mm under Sparrowvale Road, Pit 2-3=10 yr pipe to Barwon Heads Rd, Pit 3-4=Barwon Heads Rd crossing (to be duplicated/augmented for 100 year flows), Pit 4-5=Barwon Heads Road to Sewer Crossing SBRB outlet.

Figure 4
Hydraulic Gradeline Results

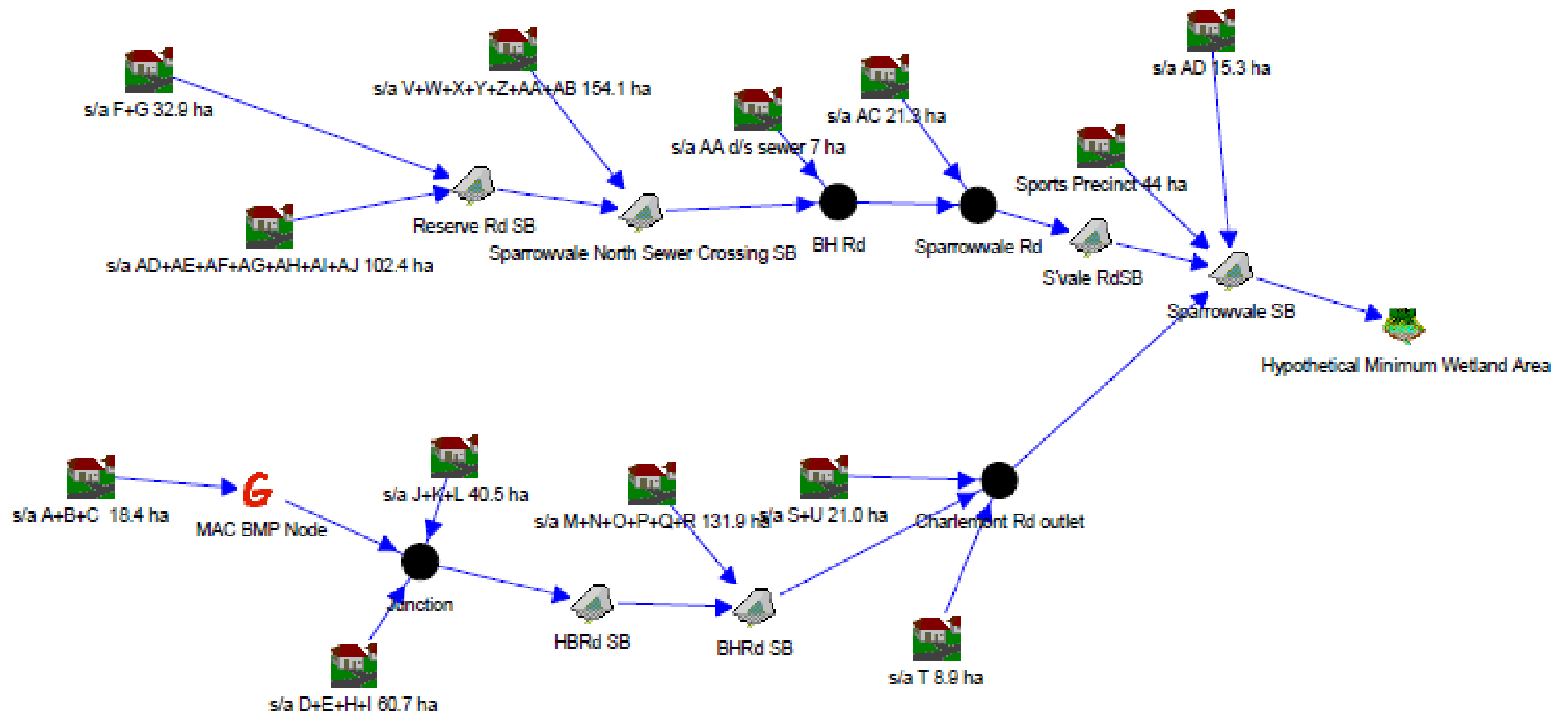


Figure 5
 MUSIC model structure for Horseshoe Bend Precinct