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CASEY GROWTH AREA

THOMPSONS ROAD PSP 53
AND
CLYDE CREEK PSP 54

STORMWATER MANAGEMENT STRATEGY (SWMS)

(FINAL DRAFT-Version 3)

11 December 2013

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1. INTRODUCTION

In partnership with Casey City Council (CCC), the Metropolitan Planning Authority –MPA (formerly the Growth Areas Authority -GAA) is managing the preparation of two Precinct Structure Plans (PSPs) known as Thompsons Road PSP 53 and Clyde Creek PSP 54. These precincts have been created as a result of the extension of the Urban Growth Boundary through Amendment V68 passed by the Victorian Government in July 2010 and the boundaries are shown on Figure 1.

Thompsons Road PSP 53 covers an area of approximately 700 ha and is expected to support a residential community of approximately 5,000-7,000 dwellings in association with 300 ha of "Business with Residential" land and a Major Town Centre. Lands generally north of the transmission easement, drain north to Ti Tree Creek (Clyde North PSP) in the Port Phillip Bay catchment. The balance areas drain south easterly into PSP 54 and Cardinia Creek in the Western Port Bay catchment.

Clyde Creek PSP 54 covers an area of approximately 1,153 ha and is traversed by the existing water course Clyde Creek which outfalls to Western Port Bay via the Western Contour Drain. Eastern areas of PSP 54 are directed to Muddy Gates Drain which also outfalls to Western Port Bay. The precinct is expected to support a residential community of approximately 15,000-17,000 dwellings and a Major Town Centre in association with a new Clyde Railway Station.

The northeast sector of PSP 57.1 drains eastwards into PSP54 at the railway. The balance drains south across Ballarto Road into PSP 58. These lands form part of the total catchment of Clyde Creek.

Management of surface water (drainage, flooding, water quality, waterway values) and protection of local environmental values and Western Port Bay are key issues across both PSP's.

This study has been commissioned by the MPA to:

- assess the current drainage and hydrological makeup of the land;
- develop a surface water management strategy (SWMS) that responds to and effectively mitigates the impacts of urban development on receiving waterways and environments;

- provide concept designs for stormwater management that detail alignment of drainage lines, location and size of retarding basins, water quality treatment wetlands, waterway setbacks, and key habitat protection and enhancement measures;

- confirm the allocation of land take in the draft urban structure plans for stormwater management infrastructure and associated mitigation works and to confirm potential future stormwater assets for Melbourne Water (MW) which will be included in future MW Development Services Schemes (DSS) for both PSPs.

The SWMS and associated designs will be used to inform the Urban Structure of both PSP's, and the DSS for Clyde Creek and Muddy Gates Drain and Cardinia Creek, in addition to updating the existing DSS for Ti-Tree Creek.

CCC has also requested that the study specifically address the issues of development staging and implementation and temporary works to deal with out-of-sequence development.

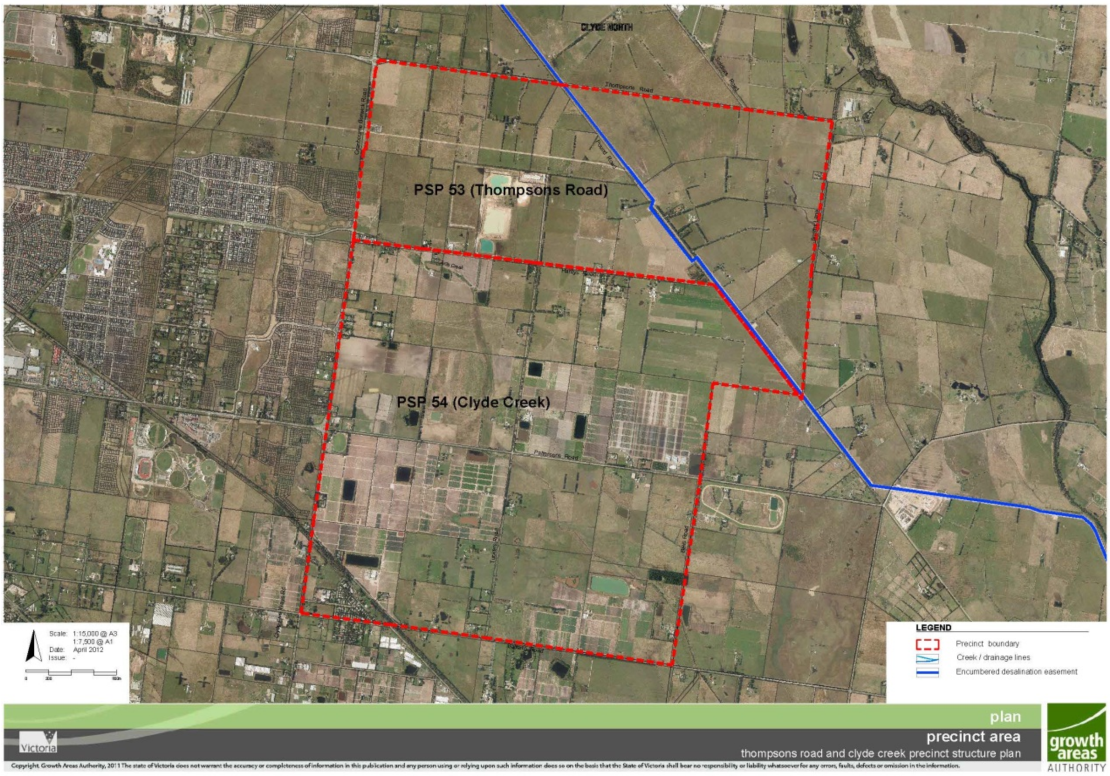


Figure 1 PSP 53 and 54 (CGA)

2. REQUIREMENTS OF THE BRIEF

Extracts from the study brief are repeated verbatim below. Where reference is made to the former GAA, this should now be taken as the MPA.

The drainage strategy shall:

1. Provide a drainage design solution that generally complies with the Precinct Structure Planning Guidelines and:
    - Incorporates design methods and innovation where possible to minimise land take.
    - Maximises the ability to utilise land set aside for drainage for open space, recreation and other urban purposes.
    - Contributes to a green urban environment with extensive tree and other planting.
    - Integrates with other proposed elements of the PSP such as town centres, education and community facilities, as well as, the quarry site.
    - Allows for appropriate maintenance access and integrates this with recreation uses where practical (e.g. access tracks/pedestrian and cycle paths).
2. Provide an overall drainage design solution that also incorporates a time allowance for iterative local drainage system design refinement in consultation with the GAA (to achieve the objectives outlined in point one above).
3. Retard water flow to pre-development levels for flow events up to the 1 in 10 year Average Recurrence Interval (ARI) level and Best Practice treatment performance, prior to entering Clyde Creek, Western Outfall Drain and Muddy Gates Drain.
4. Undertake an overall catchment assessment of Cardinia Creek and options analysis to determine the level of retardation required prior to discharge into Cardinia Creek. This analysis needs to take into account the upstream local catchment including drainage analysis for Minta Farm and the Clyde North DSS. (Stakeholder engagement will be required with MW and GAA to finalise the exact performance criteria of this catchment based on an options analysis.)
5. Retard stormwater runoff flows to the capacity of the downstream system or pre-developed flows up to 1 in 100 year events for Ti-Tree Creek to match the current assumed flows for the Ti-Tree Creek Development Services Scheme.
6. Include the concept design of a large regional flood retarding basin downstream of the Casey Growth Area (CGA) to mitigate impacts of hydrological change on flora and fauna values in estuarine reaches of Western Outfall Drain, Muddy Gates Drain and protect values in Western Port Bay.

7. Ensure the large retarding basin (RB) provides unrestricted connectivity for aquatic species movement.
8. Include the construction of low-flow habitat wetlands for aquatic species Growling Grass Frog (GGF) and Dwarf Galaxias (DG) adjacent to the main pilot channels and *must not* be used for flow retarding purposes. Design shall be consistent with Conservation Management Plans for species identified in the SKM report (2012).
9. Ensure adequate buffers are provided around wetland habitats and waterways depending on the quality of terrestrial habitat or dispersal corridors (remnant native vegetation to be retained within the buffers).
10. Enable existing channels within the CGA to be re-modelled to cater for increased flows as they have low geomorphological value (GGF and DG do not rely on these in-channel habitats).
11. Include the construction of waterways designed to protect movement opportunity of fish and other aquatic fauna between suitable habitats.
12. Determine locations and sizing of in-catchment treatment of stormwater (to Best Practice - 80% Total Suspended Solids, 45% Phosphorus and 45% Nitrogen reduction) prior to water entering Clyde Creek, Western Outfall Drain and Muddy Gates Drain or any existing or constructed wetland for habitat purposes.
13. Undertake an options analysis for the potential location of retarding basins and stormwater quality treatment assets within the CGA.
14. Prepare draft staging and timing arrangements for the large RB and CGA retarding basins, based on the likely development scenario to ensure downstream land owners and ecosystems are adequately protected.

The drainage strategy should:-

15. Quantify volumes of water that can be harvested at key locations in the system to protect waterway values, it is suggested that developments should harvest stormwater to prevent excess run-off from events up to the 1 in 1 year ARI. MW will continue to work with the GAA, South East Water and Council to ensure that any stormwater harvesting opportunity is not lost as part of the PSP planning for the area.
16. Ensure the large RB is designed to reduce the frequency of peak flow events to mitigate stormwater impacts on aquatic biota. Flow frequency should be retarded to the 1 in 2 year ARI.
17. Examine whether the large RB can also:
    - Provide additional habitat for wetland birds and other species (where the primary hydrologic function is not compromised).

- Provide flood mitigation for the downstream flood protection zone and mediate water quality issues to SEPP F8 standards at all stages of urban development. This may mean staged construction congruent with catchment development.
- Complement potential abutting regional/municipal scale active open space provision.

18. Ensure designs of RB within the CGA maximise connectivity for aquatic species.
19. Comply with SEPP F8 water quality targets for Western Port Bay. It is intended that the proposed RB/wetland downstream of the CGA will provide additional water quality treatment to achieve SEPP F8 targets.

    Based on other modelling in Western Port, the SEPP target are likely to be as high as:

    - 93% reduction in suspended solids loads.
    - 66% reduction in total phosphorus loads.
    - 63% reduction in total nitrogen loads.

    However, Melbourne Water in consultation with stakeholders will adopt a practical water quality treatment target for the stormwater discharging from the proposed large RB/wetland. It is intended that the entire stormwater system will provide stormwater treatment above the current Best Practice guidelines.

3. BACKGROUND INFORMATION

In late 2011 MW engaged SKM to assess the Casey Growth Area (CGA). The assessment included a study of environmental issues of the area including aquatic ecology, geomorphology, water quality, hydrological, cultural heritage and groundwater issues affecting Clyde Creek, Muddy Gates Drain and the Western Outfall Drain. All these drain into Western Port Bay. The study did not however cover Cardinia Creek and the small section that exists in PSP 53 will require separate investigation.

The SKM 2012 report '**Casey Growth Area Planning: Assessment of the risk to water dependant environmental values from development of the Casey Growth Area (Part A – Clyde Creek/Western Outfall Drain and Muddy Gates Drain)**' has been used to inform the SWMS.

A further study of water use and reuse across the CGA is being carried out in parallel with the SWMS. South East Water (SEW), MW and Southern Rural Water (SRW) have developed a draft **Integrated Water Management (IWM)** strategy for the South East Region of Melbourne which coincides with the extension of the urban growth boundary in the municipalities of Casey and Cardinia. The aim is to develop the optimal mix of water related solutions for the community in this region taking account the many values of water, the associated environmental footprint, optimisation of resources and infrastructure, supporting customer choice and providing community value. SEW is preparing a Servicing Master Plan for the Casey Cardinia Growth Expansion. The aim of this master plan is to develop a servicing plan with consideration given to meeting demand through non-conventional means incorporating elements of IWM. The non-conventional means include local sewerage treatment and reuse, stormwater harvesting (with potential treatment and re-use), and rainwater tanks. Outputs from the SWMS investigations (volumes and quality of surface water, location and sizing of various storage and treatment systems, will be used to directly inform SEW's options analysis.

MW have supplied detailed LiDAR survey overlaid on aerial photography for use in the investigations. Other reports and studies that have influenced development of the SWMS include:

- "Drainage, An analysis of opportunities and constraints in Investigation Areas". Beveridge Williams and Neil M Craigie P/L February 2009. This study was part of the *Melbourne@5Million* investigations and it defined an initial drainage layout for the CGA areas.

- Cranbourne East PSP drainage investigations (2009/10), including the design of the major wetland/retarding basin on Clyde Creek at Berwick-Cranbourne Rd in the Cascades on Clyde Estate.

- Clyde North PSP SWMS, October 2009 Neil M Craigie P/L.

- Southeast Urban Growth Zone, The Proposed Western Contour Drain Wetland/Retarding Basin Strategic Investigation Discussion Paper, for Melbourne Water, Neil M Craigie P/L, 13 March 2011.

- Growling Grass Frog Corridor review investigations, Biosis Research and Neil M Craigie 2012 (in prep for DSE/DEPI), which assessed locations and sizing for all primary habitat pond assets in the CGA areas.

Detailed cross-sectional survey of the Western Contour Drain and Muddy Gates Drain has also been commissioned by MW to allow hydraulic capacities of both systems to be determined. This information is of critical importance to inform the design of the major southeast wetland/retarding basin (referred to as the SE WLRB).

The RORB[1] hydrologic model and MUSIC[2] water quality model have been used for all investigations in this study.

[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.

4. DESIGN CRITERIA AND ASSUMPTIONS

4.1 Flood Storage Systems

The process of urbanisation dramatically increases impervious areas (increasing the proportion of rainfall which becomes surface runoff) and modifies the drainage system characteristics through piping of minor catchments and construction of open waterways (typically reducing the response time for surface runoff). The net hydrologic impact in the absence of appropriate countermeasures is significantly increased peak discharges, volumes and frequency of surface runoff events.

To offset the impacts of increased peak discharges, flood retarding storages are provided and constructed open waterways are designed to slow velocities. However retarding storages have little effect on volumes or frequency of runoff events and it can be these impacts which are of most concern for ecological conditions in receiving natural waterways, as well as for downstream rural landowners.

The SKM report has found that the receiving waterways in PSP 53 and 54 (and downstream in PSP 55 and 56) have been so modified that there are negligible remnant environmental values, apart from the Category 1 Growling Grass Frog (GGF) corridor in the lower end of Clyde Creek. However the report also emphasises that there are opportunities to restore and rehabilitate naturalised open waterways with improved values as part of overall drainage planning. Similar conclusions apply for the northern parts of PSP 53 which drain to Ti Tree Creek and Port Phillip Bay.

Hence for the purposes of developing this strategy it has been assumed that:

- there are no ecological obstacles to construction of new naturalised waterways to replace the existing (largely artificial) alignment of Clyde Creek upstream of the GGF corridor;

- similarly there are no ecological obstacles to construction of pipelines and new naturalised waterways to replace the existing artificial alignment of Muddy Gates Drain and its tributary drains and the constructed drains in the Ti Tree Creek catchment;

- design of new waterways should aim at maximising potential habitat, recreational and landscape values, in addition to providing flood conveyance at minimum velocities;

- water quality treatment will be required on all tributary catchments to protect restored values in the open waterway systems, as well as the ultimate downstream receiving environments;

- online wetland and pondage systems may also be implemented as part of the water quality treatment trains where topography creates the opportunities, provided that such assets can be designed to comply with MW guidelines and do not create significant ecological barriers;

- wetland and pondage systems can and should be integrated with flood storage wherever feasible.

It is recognised that land values in town centres and other activity centres and industrial zones will usually favour the use of pipelines rather than open waterways wherever hydraulically and environmentally feasible. Current policy settings also discourage open waterways passing through schools and major active open space land.

Integrated flood retarding storage and water quality treatment pondages take two main forms:

- Sediment basin/retarding basins (SBRB's);
- Wetland/retarding basins (WLRB's).

Wetlands and sediment basins that are not intended to provide flood retarding storage (ie., those for which airspace volume is only sufficient to provide for the necessary extended detention storage for water quality treatment) are labelled as WL's and SB's respectively.

Water surface areas are sized to comply with specified water quality treatment standards. In conjunction with the relevant level constraints and batter slopes, this in turn then determines the potential flood storage capacity in the airspace above the water surfaces.

It follows then that selection of the appropriate design forms is dependent to a large degree on the adopted water quality treatment protocol to be followed across the CGA, as well as on topographic opportunity, environmental values and planning proposals.

4.2 Water Quality Treatment Protocol

Water quality treatment standards are quoted as percentage removal of the typical urban loads of Gross Pollutants/Total Suspended Solids/Total Phosphorus/Total Nitrogen (GP/TSS/TP/TN). Current best practice standards are 70/80/45/45 per cent removals of the typical urban loads. Gross pollutants are removed in either purpose built traps or sediment basins and wetlands. Whatever technique is used GP removal does not impact on water surface area or flood storage systems. Hence the focus of this strategy is on TSS/TP/TN removals.

From the guiding objectives set out in the brief and after consideration of the results of the SKM study for the southerly draining catchments to Western Port, the appropriate water quality treatment protocol across the CGA is summarised as follows:

(a) Ti Tree Creek

- Subcatchments connecting to Clyde North PSP at Thompsons Road-best practice 80/45/45 at Thompsons Road.

(b) Clyde Creek

The proposal is to reconstruct as a naturalised open waterway with integrated WLRB's, downstream of Berwick-Cranbourne Road to Tuckers Road, and thence to generally retain and enhance the existing waterway downstream to Ballarto Road.

- Subcatchments connecting to Clyde Creek upstream of the GGF 1 corridor-best practice 80/45/45 at or upstream of connection point.

- Landholdings directly abutting Clyde Creek-70% TSS removal at or upstream of connection point if nutrient treatment facilities are in place downstream, or 80/45/45 if developed in advance of such downstream facilities.

- At the commencement of the GGF 1 corridor-80/45/48 for total catchment (to account for possible Class A recycle supply use across catchment). Note: 48% TN removal automatically achieves far greater TSS and TP removal than best practice.

(c) Muddy Gates Creek

The proposal is to reconstruct as a naturalised open waterway downstream of Pound Rd. This is external to PSP 53 and 54.

- Subcatchments exiting from PSP 53/54 boundary (Bells Rd and Pound Rd)-best practice plus Class A offset (80/45/48) at or upstream of boundary discharge point.

- Landholdings directly abutting Muddy Gates Creek-70% TSS removal at or upstream of connection point if nutrient treatment facilities are in place downstream, or 80/45/45 if developed in advance of such downstream facilities.

- Future PSP 55 and 56 areas downstream of PSP53 and 54 should achieve the same standards at or upstream of Ballarto Road and at the UGB boundary to the south (80/45/48).

(d) Downstream of Ballarto Road – the SE WLRB and the creek outfalls.

The major WLRB system proposed to serve the CGA has two segments. The first segment is south of Ballarto Rd between Western Contour Drain and Muddy Gates Drain with the railway forming the south boundary. This segment is the focus of this current investigation.

The second segment is south of the railway with Manks Road generally forming the southern boundary. This segment will service the future PSP 56 and 57 catchments to the west of PSP 54, south of the railway.

> *(Firstly it is recommended that the drains be renamed as Clyde Creek and Muddy Gates Creek all the way to the Western Port Bay outfalls).*

The SE WLRB should be the focus of additional water quality treatment (as well as flood storage), to get to <u>SEPP F8 standards (93/66/63) at the railway outfalls</u>.

There is no logical reason why standards higher than those outlined above should be applied upstream of Ballarto Road unless the modelling shows that the SE WLRB alone cannot get the required extra treatment capacity to get to SEPP F8 at the outlets.

(e) Catchment flowing southeast to Cardinia Creek

- As for Muddy Gates Creek discharges-80/45/48 at PSP 53 boundary.

- The future PSP 55 should include additional treatment assets within/around the GGF corridor sufficient to get to SEPP F8 standards at the outfall to Cardinia Creek downstream of McCormacks/Chasemore Rd.

(f) Water Reuse

The beneficial impacts of water reuse in support of or in lieu of treatment and disposal to the drainage system have not been factored into the above protocol. It is considered that until such time as an agreed strategy is in place locking in such reuse, the drainage strategy must assume no reuse for the purposes of sizing treatment facilities across the drainage system.

4.3 Cross PSP Boundary Issues in the Western Port Catchment

Opportunities for surface water management assets do not always match the PSP boundaries. Topographic, environmental and/or cultural/heritage constraints should always be considered when locating assets.

In many drainage lines exiting from PSP 53 and 54, overall drainage scheme planning would favour locating wetland systems downstream of these PSP boundaries. Similarly there are opportunities for assets in the downstream PSP 55 and 56 areas to be moved into the future SE WLRB. Cost offsets for all such asset transfers can be resolved via the MW DSS.

It has been agreed by MW/MPA that the strategy should be founded on best matching overall opportunities and constraints (and planning constraints) to locate main drainage assets across the CGA.

This means that some site-specific variations to the water quality treatment protocol set out in Section 4.2 should/could occur.

For the balance of PSP 53 and 54 the variations which are recommended and factored into the modelling are as follows:

(a) Muddy Gates Creek Catchment

- Bells Road/Pattersons Road outfall-sediment removal to >= 70% TSS within PSP 53 and the balance to best practice standards downstream in PSP 55.

- Pound Road outfalls- sediment removal to >= 70% TSS within PSP 53 and 54 and the balance to best practice standards downstream in PSP 55.

(b) Clyde Creek Catchment

- The area of land on the east side of Berwick-Cranbourne Road north of Pattersons Road to Heather Grove roundabout drains westerly into the Collison Road DSS. That DSS has provided for full development of the land in PSP 54 so that on payment of the necessary contributions, no retardation storage or water quality treatment assets are required within the PSP 54 land.

- Pipeline diversion of southeasterly draining outfalls along Ballarto Road between the railway and Clyde Creek, eastwards to a common outfall at the future Moores Road/Bells Road intersection. All water quality treatment infrastructure for PSP 54 land to be consolidated downstream in PSP 56.

Similar variations may also arise in PSP 55 and 56 areas as a consequence of the opportunities associated with development of the SE WLRB.

(c) PSP 56

- Realignment of Clyde Creek eastwards from the Bells Road extension reservation to provide space for some of the required assets for the Ballarto Road outfalls to be moved out of the UGB area.

- Relocation of assets on the railway tributary out of the UGB into land between the Bells Road extension and Clyde Creek. On the Moores Road/Railway tributary the terminal WLRB has been located on the highly constrained floodplain east of the UGB boundary.

(d) PSP 55

- Relocation of some of the assets in Muddy Gates Creek onto the south side of Ballarto Road, out of the UGB and into the SE WLRB.

These variations are external to PSP 53 and 54 and may be considered in more detail in a later study.

4.4 Ti Tree Creek Discharge Requirements

For those parts of PSP 53 draining north into Ti Tree Creek there is no opportunity to adjust the water quality treatment protocol due to agreed development layout and treatment area sizings north of Thompsons Road in the Clyde North PSP. All land south of Thompsons Road was assumed to remain rural in design of the Clyde North PSP.

Thus best practice water quality standards must be achieved in all outfalls at Thompsons Road.

This also applies to permissible peak discharges across Thompsons Road. No increase in peak discharge is permitted for ARI's up to and including the 100 year ARI event.

4.5 Cardinia Creek Outfall Catchment Requirements

As part of this current investigation a review of the hydrologic and hydraulic modelling of the Cardinia Creek and outfall to Western Port Bay has been carried out.

The brief required this review to be completed to confirm peak flow mitigation requirements for CGA lands draining to Cardinia Creek at McCormacks/Chasemore Road. Hydraulic capacity of Cardinia Creek Outfall is of critical importance to management of the Koo Wee Rup Flood Protection District and increased discharges and volumes of runoff from urban growth areas has the potential to exacerbate flooding problems.

Only 85 ha of development land in PSP 53 drains to this outfall so that the predominant impacts of future urban development will be associated with PSP 55.

The review has culminated in a revised report on the total Cardinia Creek catchment to Western Port Bay[3].

The revised report has concluded that if wetland systems are provided for best practice water quality treatment in PSP 53 and the abutting land in PSP 55, the airspace storage capacity above the wetland systems will suffice to offset impacts on peak flows for smaller flood events (which are of concern for waterway stability and ecological protection) and no additional peak flow mitigation is needed to manage runoff in large events up to and including the 100 year ARI flood.

3 Assessment of Drainage Strategy for PSP 53 and the Overall Cardinia Creek Catchment, 24 September 2012, Stormy Water Solutions, Neil M Craigie P/L and Pat Condina & Associates

It follows then that if wetlands are not provided in these development areas, additional storage capacity will have to be provided to maintain pre-development flows to existing conditions for those smaller flood events.

This SWMS adopts wetlands to meet best practice standards in the Cardinia Creek catchment, with some variation to suit the adopted water quality treatment protocol within the CGA as set out in Section 4.2.

5. RORB MODEL STRUCTURES

5.1 Clyde Creek/Muddy Gates Creek Catchment

5.1.1 RORB Model Structure used for Prior SE WLRB Investigations

The tributary drainage catchments and subcatchments are shown on Figure 2 and quantified in the model datafile.

For all new UGZ areas an average imperviousness of 55% was adopted for developed conditions, including all green space across the area.

For existing conditions all subareas were modelled using 5% imperviousness as per MW modelling policy.

The *Melbourne @ 5 million* investigation identified a likely layout for all future main waterways and provided recommendations for minimum reserve widths for each. The basic premise was that open "naturalised" waterways and linear wetland systems would dominate throughout the UGZ area, with piping used for smaller urban development parcels only.

Piping was assumed to be limited to those catchment sizes where an 1800 mm diameter maximum pipeline could carry peak 5 year ARI flows and residual overland flows could be conveyed in a roadway whilst complying with floodway safety guidelines as set out in Appendix A of the MW Land Development Manual. Typically most of the 1st order waterways on the RORB plan were assumed to be piped.

Figure 2 shows the general alignments of the main waterway reserves as was adapted from the *Melbourne @ 5 million* investigation.

It may be noted that some diversions are proposed on the Manks Road frontage west of the Western Contour Drain (WCD):

- Subareas BB-BF inclusive to include a pipeline diversion for all flows up to and including a nominal 1 m^3/s limit, across to the next valley line (subarea BG);

- Subarea BG to be fully diverted as an open waterway to the next valley line (subareas BH-BI inclusive);

- Subareas BH-BI to be fully diverted to join with subareas BJ-BN inclusive and thence outfalling to the WCD, all as open waterway.

For the purposes of RORB modelling the following protocol was adopted for reach classification for developed conditions:

- Most 1^{st} order waterways on the RORB plan (Figure 2) are piped and Code 3 is applied at average grade of 0.5%);

- Open waterway reserve widths of 40-60 m were assumed to be designed for conveyance primarily and were modelled as Code 2 with default average grade of 0.5%;

- Open waterway reserve widths of 80 m or more were modelled as Code 1. This applies to linear wetland systems as well as major open naturalised waterways and the existing Clyde Creek and Western Contour Drain.

5.1.2 Peak Flow Estimates for Existing Conditions

The RORB model shown on Figure 2 was set up to represent existing conditions and run to produce peak flow estimates for ARI's of 1, 10 and 100 years. These discharges form the basis for assessment of future developed conditions flood management requirements.

The model parameter values were as follows:

- K_c = 13.00, m = 0.8,
- Pervious area initial loss = 10 mm
- Pervious area runoff coefficients (CRO_p) = 0.6 (100 yr), 0.55 (50 yr), 0.50 (20 yr), 0.40 (10 yr), 0.30 (5 yr), 0.25 (2 yr) and 0.20 (1 yr).
- The model d_{av} = 5.50 km.

The results are summarised in Table 1.

TABLE 1 Peak Discharges for Existing Catchment Conditions and varying ARI (m3/s) (Critical durations in parentheses)				
Waterway	**Location**	**1 year ARI**	**10 years ARI**	**100 years ARI**
Clyde Creek	Hardys Road	2.5 (36)	5.3 (36)	10.1 (30)
	Tuckers Road	2.8 (48)	7.2 (48)	17.4 (30)
	Ballarto Road	2.6 (48)	7.1 (36)	16.2 (30)
Western Contour Drain	Confluence d/s Ballarto Road	2.9 (48)	8.8 (36)	21.0 (30)
	Railway	3.2 (48)	10.5 (36)	25.7 (30)
Muddy Gates Drain	Pattersons Road	0.6 (36)	1.8 (9)	4.9 (12)
	Ballarto Road	1.8 (36)	6.1 (9)	16.5 (12)
	Confluence d/s Ballarto Road	2.0 (36)	6.7 (9)	18.0 (24)
	Railway	2.0 (48)	6.8 (24)	18.1 (24)

The Ti Tree Creek RORB model used for the Cranbourne West and Clyde North PSP's was run to produce peak flow estimates for the 100 year ARI event at the two outfall points provided for PSP53 catchments at Thompsons Road.

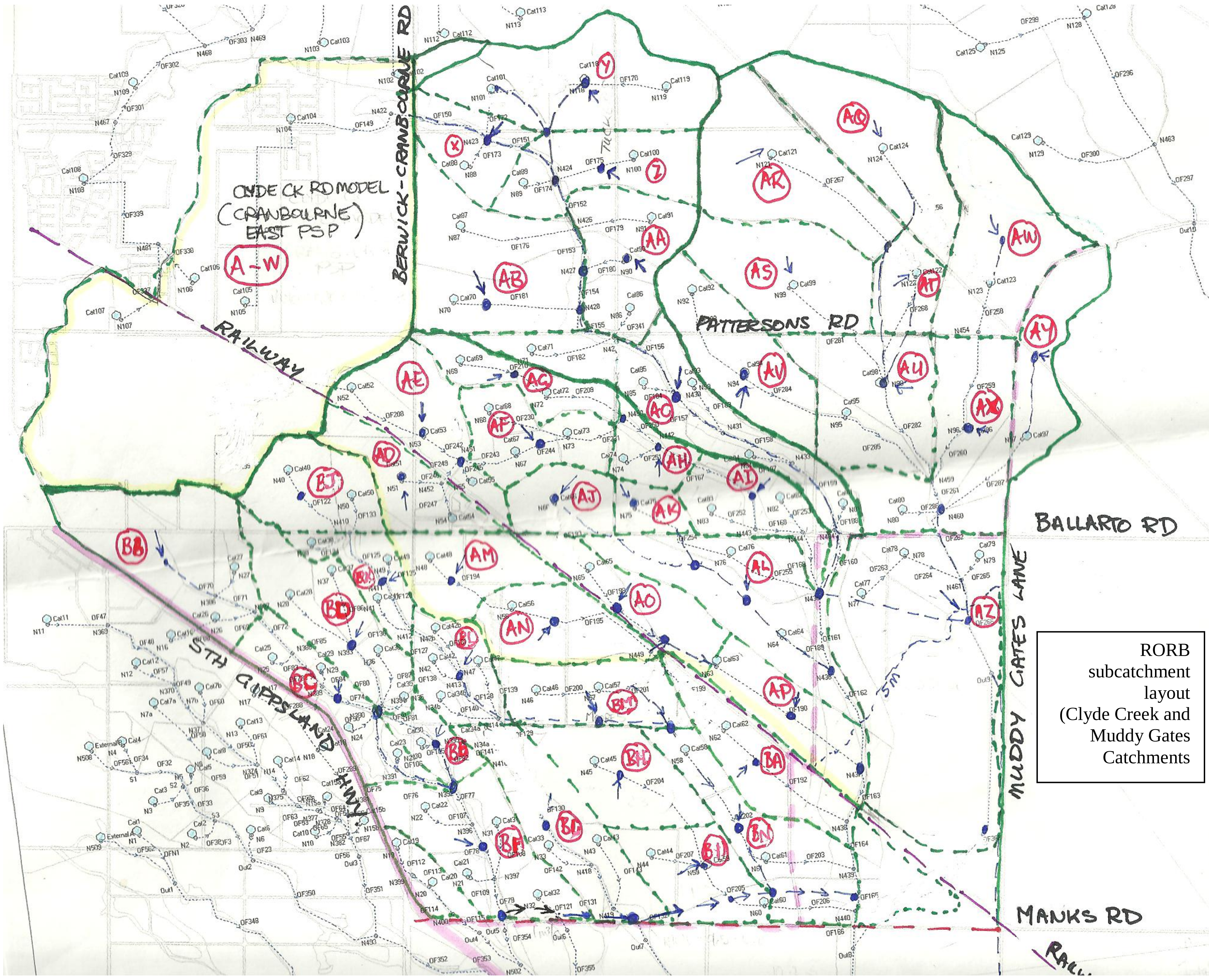
All land within the PSP 53 boundaries was assumed to be rural in that model structure.

The model parameter values were as follows:

K_c = 11.00, m = 0.8,
Pervious area initial loss = 10 mm
Pervious area runoff coefficients (CRO_p) = 0.6 (100 yr), 0.55 (50 yr), 0.50 (20 yr), 0.40 (10 yr), 0.30 (5 yr), 0.25 (2 yr) and 0.20 (1 yr).

The results are summarised in Table 2. These discharges form the limiting outflows from PSP 53 for future developed conditions.

TABLE 2 Peak Discharges for 100 years ARI (m3/s) (Critical durations in hours in parentheses)	
Location	**Peak discharge**
Thompsons Road (west outfall)	6.0 (9)
Thompsons Road (east outfall)	6.1 (9)



RORB subcatchment layout (Clyde Creek and Muddy Gates Catchments)

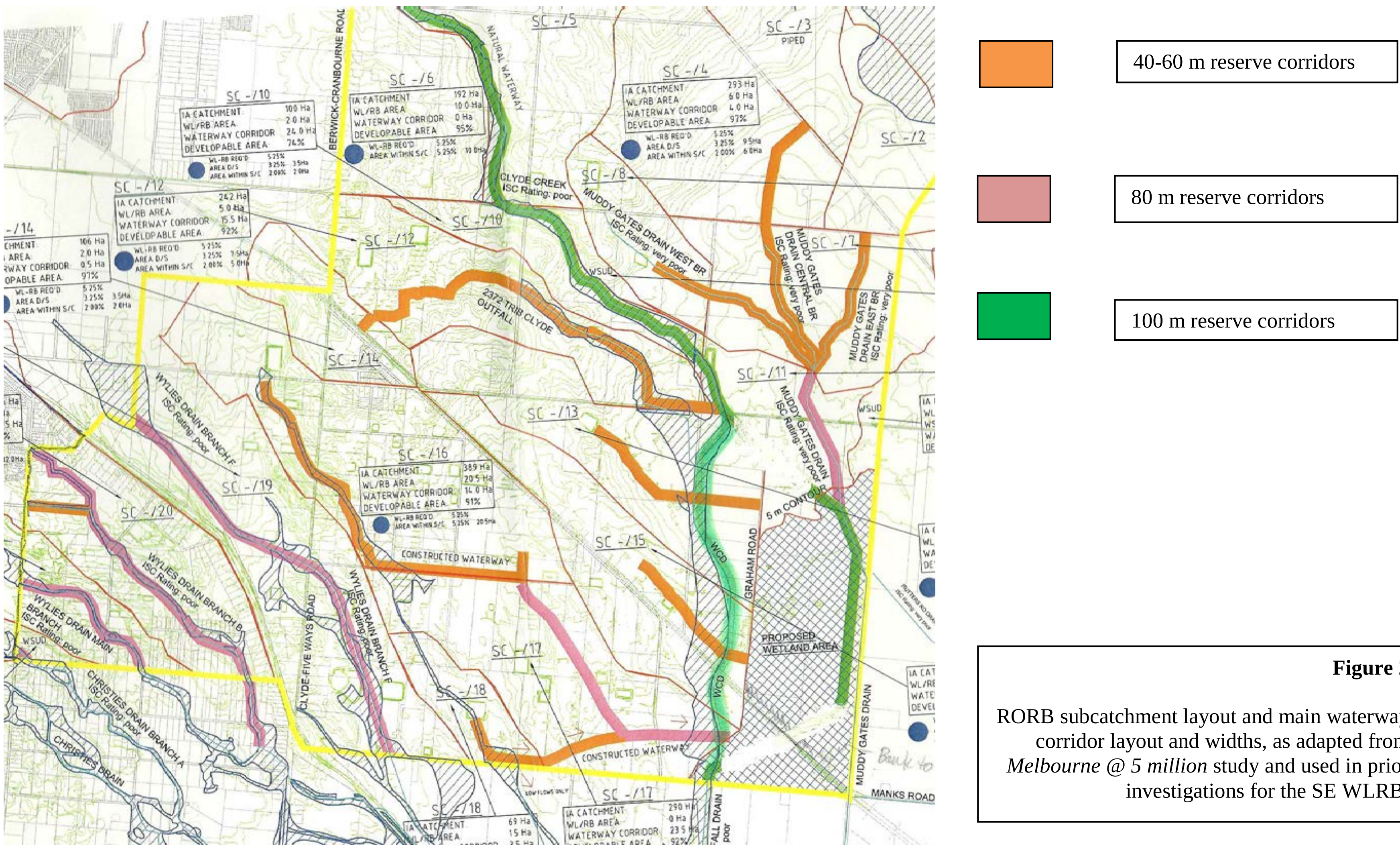


Figure 2

RORB subcatchment layout and main waterway corridor layout and widths, as adapted from *Melbourne @ 5 million* study and used in prior investigations for the SE WLRB.

5.1.3 Amended RORB Model Structure Used in this Investigation

5.1.3.1 Subarea Imperviousness

In accord with most recent policy adjustments, an average imperviousness of 60% has now been adopted for conventional residential lands, with 80% for medium residential and 90% for high density residential/town centre commercial/industrial areas. These figures include all local scale green space across the area but not major open space precincts.

5.1.3.2 Subarea and Drainage Setup

For consideration of waterway and subcatchment treatment requirements within the PSP 53 and 54 areas, the model structure used in the SE WLRB study is too coarse and further subarea discrimination has occurred for current study purposes. It was necessary to refine subarea and drainage layout within PSP 55 and 56 areas, and to exclude land draining into the Collison Road DSS as well.

In determining the final layout shown on Figure 3 the following considerations have been taken into account:

- Land ownership/title boundaries;
- PSP planning layout including main road infrastructure, proposed activity centres and associated higher density development, and major active open space;
- Desalination pipeline constraints;
- Growling grass frog corridor requirements;
- Topographic constraints and opportunities.

The model K_c parameter value is changed from 13.00 to 16.45 to maintain the same K_c/d_{av} ratio as for the existing conditions model.

5.2 Ti Tree Creek Catchment

5.2.1 Peak Flow Estimates for Existing Conditions

The Ti Tree Creek RORB model used for the Cranbourne West and Clyde North PSP's was run to produce peak flow estimates for the 100 year ARI event at the two outfall points provided for PSP53 catchments at Thompsons Road. All land within the PSP 53 boundaries was assumed to be rural in that model structure.

The model parameter values were as follows:

K_c = 11.00, m = 0.8,
Pervious area initial loss = 10 mm
Pervious area runoff coefficients (CRO_p) = 0.6 (100 yr), 0.55 (50 yr), 0.50 (20 yr), 0.40 (10 yr), 0.30 (5 yr), 0.25 (2 yr) and 0.20 (1 yr).

The results are summarised in Table 2. These discharges form the limiting outflows from PSP 53 for future developed conditions.

TABLE 2 Peak Discharges for 100 years ARI (m3/s)
(Critical durations in parentheses)

Location	Peak 100 yr ARI discharge
Thompsons Road (west outfall)	6.0 (9)
Thompsons Road (east outfall)	6.1 (9)

5.2.2 Amended RORB Model Structure Used in this Investigation

5.2.2.1 Subarea Imperviousness

In accord with most recent policy adjustments, an average imperviousness of 60% has now been adopted for conventional residential lands, with 80% for medium residential and 90% for high density residential/town centre commercial/industrial areas. These figures include all local scale green space across the area but not major open space precincts.

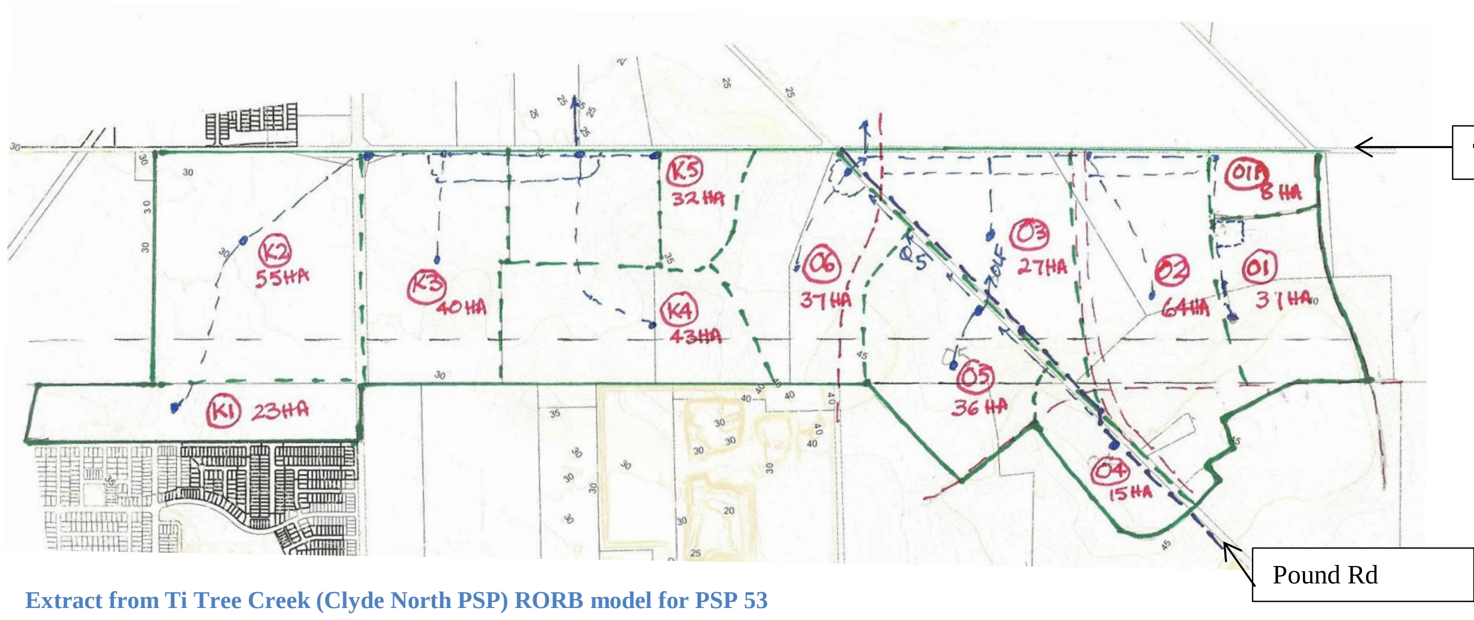
The majority of the land is proposed for industrial or commercial purposes with some residential areas on the higher slopes. The transmission easement was assumed to be 10% impervious.

5.1.3.2 Subarea and Drainage Setup

The original model structure included 3 subareas for the eastern outfall and just one for the western outfall. The modified structure further subdivided the catchments to 7 and 5 subareas for the east and west outfalls respectively as shown on Figure 3.

In determining the final layout shown on Figure 3 the following considerations have been taken into account:

- Land ownership/title boundaries;
- Preliminary PSP planning layout including main road infrastructure, proposed activity centres and associated higher density development, and major active open space;
- Desalination pipeline constraints (east outfall only);
- Topographic constraints and opportunities;
- Defined outfall locations at Thompsons Road and fixed receiving water levels and flood levels in Clyde North PSP.



Extract from Ti Tree Creek (Clyde North PSP) RORB model for PSP 53

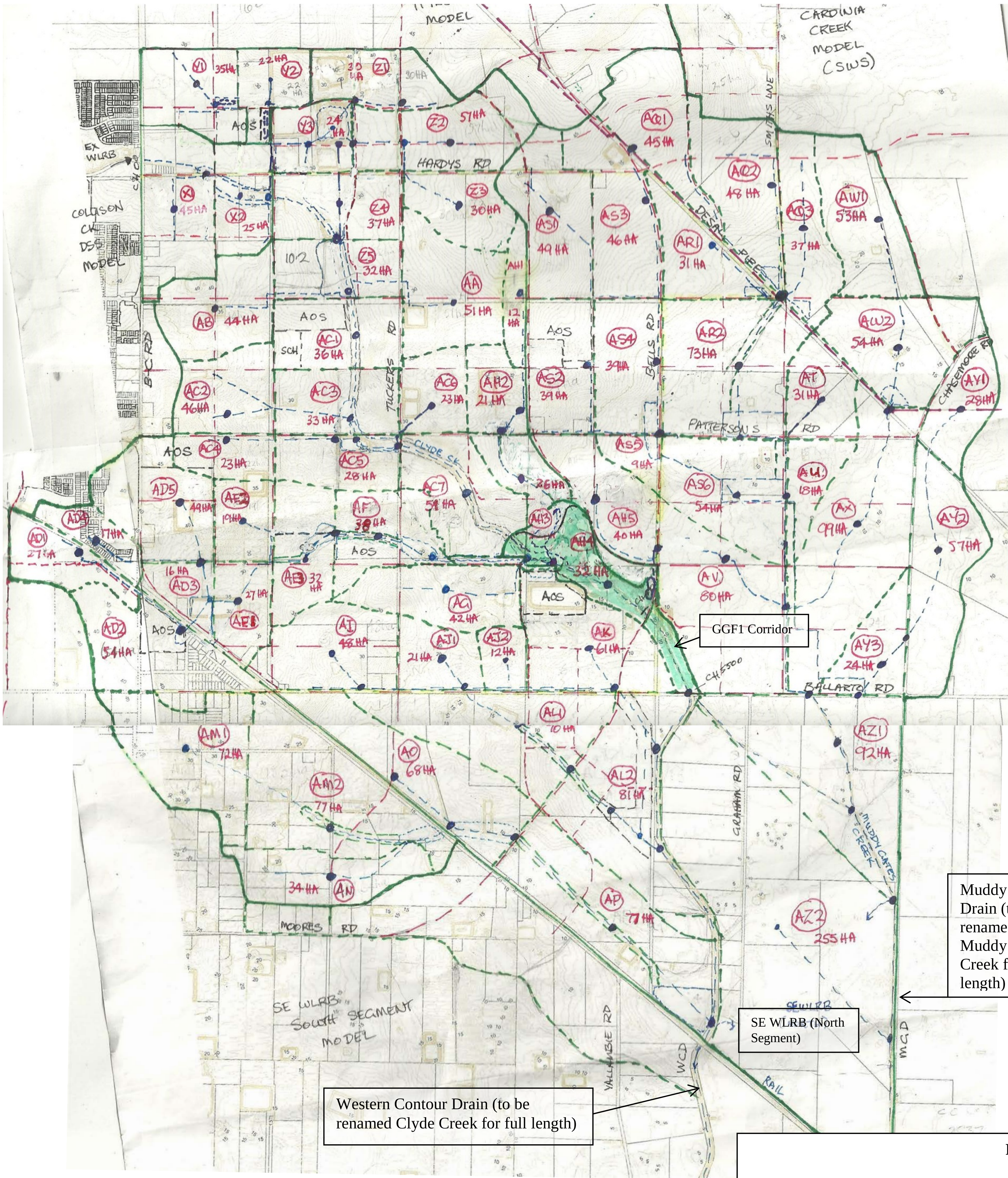


Figure 3

Amended RORB subcatchments and waterway layouts as derived in this investigation

5.3 Siting of the Proposed Major Stormwater Management Assets

The sites identified on Figure 4 are considered to best suit the identified constraints and opportunities based on the current PSP layouts.

Table 3 summarises the reasoning behind the locations and sizings of the selected sites shown on Figure 4.

There is certainly scope to modify tributary SBRB and WLRB layouts and locations if further changes can be accommodated in the PSP layout and land outside the UGB does become available for use in PSP water management.

The PSP layout and assets shown on Figure 4 have already been modified several times during the course of this current investigation in response to:

- preliminary hydrologic and water quality modelling results;
- negotiations on environmental constraints (the GGF corridor in Clyde Creek);
- MPA planning inputs;
- MW drainage comments;

Most recently modifications have been made to asset shaping and layout to best respond to development proposal inputs from many of the affected landowners. The Hardys Road town centre catchment and asset changes are perhaps the prominent of these modifications.

Notwithstanding all the detail modifications made to date, Figure 4 should still be considered as being subject to further modification. With this in mind Table 3 also includes a discussion of possible options that have occurred to the writer during the investigation.

The MUSIC model V3 was used to determine water surface areas in each case, according to the water quality treatment protocol set out in Section 4.2 and as varied in Section 4.3. Those results are listed in Section 7.

Table 4 in Section 6 summarises the key physical characteristics of all the assets shown on Figure 4.

Concept layouts for the primary assets are shown overlaid on the 0.5 m LiDAR survey data on Figure 5 (Sheets 1-2), Figure 6 (Sheets 1-6), and Figure 7 (Sheets 1-2).

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
			TI TREE CREEK CATCHMENT		
WLRB1	• Very flat topography in east-west direction favours long linear waterbody to shorten pipe runs and minimise filling. • Utilises land that is poorly drained and requires some fill anyway. • Proposal should provide reasonable balance of cut/fill volumes. • Created by excavation with no embankments.	• No significant remnant values.	• NTWL is sensitive to downstream receiving levels. • Ti Tree Creek NTWL is proposed at 22.30 m and is 600 m+ away. • Likely finished surface level of Thompsons Road is ~25.75 m so 100 year ARI level <=25.50 m and upstream finished surface level is >=26.35 m. • Cover also controls levels. • Maximum feasible single outlet pipe size is 1500 mm with invert >=23.20 m. • NTWL of 23.70 m allows for maintenance drain down of up to 0.5 m.	• Linear waterbody system provides effective buffer to high volume traffic corridor. • Suits current layout north and south of Thompsons Rd. • Retains high value corner development area at Thompsons Road/Berwick-Cranbourne Road intersection.	• It is possible to vary width and length of layout to best suit subdivisional layout and maximise aesthetic outcomes. • No alternative to providing the area on the south side of Thompsons Road, unless alternative land purchased for the purpose to the north in the Clyde North PSP, to allow splitting of basin. • NTWL could be lowered by up to 0.5 m if necessary (which would eliminate gravity drain down capacity).
SBRB1	• Utilises land that is otherwise developable if not for the constraints posed by the desalination pipe. • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• NTWL fixed at 25.2 m by clearance to desalination pipe. • Surcharge level over Pound Road to be maintained at 26.3 m. • Sizing is sufficient to	• Suits current layout but would not have been required if desalination pipe had been designed to suit future development drainage.	• Not with current road layout and desalination pipe controls.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
			meet best practice sediment removal. • Shallow wide box culverts must be provided across the desalination pipe reserve to comply with cover restrictions. • 3 no.1.2*0.45 m RCB units required for the crossing.		
WLRB2a+b+c	• Extremely flat topography in east-west direction favours long linear waterbody/ies to shorten pipe runs and minimise filling. • Link pipe arrangement allows benefits of linear waterbody to be extended further along Thompsons Road without increasing water surface area. • Utilises land that is very poorly drained and requires major fill anyway. • Proposal should provide reasonable balance of cut/fill volumes. • Created by excavation	• No significant remnant values.	• NTWL is sensitive to downstream receiving levels. • Soldiers Creek NTWL is proposed at 23.50 m at the corridor link on the north side of Thompsons Rd. • Likely finished surface level of Thompsons Road is ~26.30 m so 100 year ARI level <=26.00 m and upstream finished surface level is >=26.60 m. • Cover also controls levels. • Maximum feasible single pipe size is 1650 mm with invert of 23.50 m. Two pipes needed. • NTWL of 23.70 m allows	• Linear waterbody system provides effective buffer to high volume traffic corridor. • Suits current development layout north and south of Thompsons Rd.	• It is possible to vary width and length of layout to best suit subdivisional layout and maximise aesthetic outcomes. • It is possible to add more link pipe systems to rearrange total water surface area and achieve optimal earthworks volumes (east-west and north-south). • No alternative to providing the area on the south side of Thompsons Road, unless alternative land purchased for the purpose to the north in the Clyde North PSP. • NTWL could be lowered

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	with no embankments.		for minor maintenance draindown.		to 23.50 m if necessary (which would eliminate gravity drain down capacity).
SBRB2	• Flat topography allows this asset to be located to best suit development layout. • Utilises land that is very poorly drained and requires fill anyway. • Proposal should provide reasonable balance of cut/fill volumes. • Created by excavation with no embankments.	• No significant remnant values.	• NTWL is set marginally higher than downstream in WLRB2a+b+c to allow for some maintenance drain down capacity. • Sizing is sufficient to meet best practice sediment removal.	• Suits current layout proposals for development.	• Flat topography allows this asset to be located to best suit development layout. • Could be moved to Thompsons Road at Soldiers Road intersection. • Could be reshaped. • NTWL could be lowered to match WLRB2a+b+c if necessary (which would eliminate gravity drain down capacity).
CLYDE CREEK CATCHMENT					
SB1 (Clyde Ck)	• Suits local drainage inputs from titles on west side of north-south road. • Utilises land mostly subject to inundation and where a minimum reserve width of 60 m would be required. • Created by excavation with no embankments.	• No significant remnant values.	• Allows direct connection of pipes. • NTWL of 26.5 m allows for maintenance drain down.	• High visibility and accessibility. • Contained within creek reserve and suits development layout.	• Not within the stream corridor. • An alternative site would represent loss of developable land.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
WLRB1 (Clyde Ck)	• Existing online dam has blocked Clyde Creek and dammed water through Hardys Road to Berwick-Cranbourne Road and must be removed. • Utilises land mostly subject to inundation and where a minimum reserve width of 60 m would be required. • Created by excavation with no embankments other than the north-south road formation.	• Online wetland can be created without severing fish passage. • No significant remnant values.	• Critical level to restore drainage to existing submerged culverts under Hardys Road and Berwick-Cranbourne Road. In turn is dependent on WLRB3 level downstream. • Sizing is the maximum that can be created on the site given existing levels and titles and roads. • Sizing is still not sufficient to gain best practice outcomes in Clyde Creek at the outlet.	• Suits current development layout. • Inlet culverts can be angled under Hardys Road intersection. • Downstream control created by road crossing and culverts. • Good visibility and accessibility.	• Best suits existing topography and there is no alternative site upstream, or downstream before WLRB3.
SBRB2a and 2b	• Twin-cell setup with linking balance pipe allows very flat northern catchment to be drained without major filling. • Created by excavation with no embankments.	• No significant remnant environmental values.	• NTWL cannot be raised without creating major filling upstream in the north. • NTWL is dependent on provision of deeper drainage invert downstream in WLRB1.	• Will partly abut proposed active open space. • Creates high visibility/accessibility along roads, especially to town centre. • Allows town centre wetlands catchment to be minimised by diverting northwest catchment to WLRB1.	• Both cells are required but some flexibility exists to move/realign them to best suit development layouts. •
WLRB2/BRS1	• Utilises existing quarry excavation which requires rehabilitation anyway. • Created by	• Nil	• Sizing is minimised by northwest catchment diversion to WLRB1. • Sizing is sufficient to	• Matches current PSP and development layout proposal. • Will create major	• If the quarry is not used in the DSS an equivalent asset would be relocated south of Hardys Road in

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	excavation/infill of existing quarry with no embankments.		achieve best practice outcomes for entire town centre catchment at outlet to Clyde Creek. • NTWL is dependent on WLRB3 downstream and cannot be lowered. •	aesthetic asset in town centre. • 100 year ARI outflows from town centre catchment easily piped to Clyde Creek at WLRB3 (1350 mm nominal diameter).	the Villawood land. • This would not change size or location of WLRB3 which is already maximised for topographic constraints.
WLRB3 (Clyde Ck)	• Utilises land mostly subject to inundation and where a minimum reserve width of 60 m would be required. • Created by excavation with no embankments other than east-west road formation.	• Online wetland can be created without severing fish passage. • No significant remnant values.	• Critical location to provide drainage outfall for entire town centre area, and for Clyde Creek upstream. • Also suits local subcatchment drainage inflows. • Sizing is the maximum that can be created on the site given existing levels and titles and roads. • Sizing is still not sufficient to gain best practice outcomes in Clyde Creek at the outlet.	• Suits current development layout. • Flanks north-south roadway on easterly frontage. • High visibility and accessibility from roads and valley slopes.	• No alternative site downstream in the narrow floodplain before WLRB4 at Pattersons Road.
WLRB4/BRS2 (Clyde Ck)	• Existing online dam has blocked the Clyde Creek floodplain and must be removed. • Utilises land mostly subject to inundation and where a minimum reserve	• Online wetland can be created without severing fish passage. • No significant remnant values-site is largely completely disturbed.	• Suits local subcatchment drainage inflows. • Sizing is the maximum that can be created on the site given existing levels and titles and roads.	• Suits current development layouts. • Straddles Pattersons Road and uses Tuckers Road as the downstream control. • High visibility and	• No alternative site downstream in the narrow steep floodplain before the start of the GGF 1 corridor. • No suitable sites in the tributaries.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	**Topography Considerations**	**Environmental/Cultural Heritage Considerations**	**Drainage Level/Flow/Quality Control Considerations**	**PSP/Development Layout Considerations**	**Any other option?**
	width of 60 m would be required. • NTWL suits existing downstream waterway and facilitates construction of new waterway upstream to WLRB3. • Created by excavation with no embankments other than Tuckers Road formation.		• Sizing is only just sufficient to gain best practice outcomes for TN in Clyde Creek at the outlet.	accessibility from main roads and valley slopes.	
SBRB3 (Station Ck)	• Utilises vacant land abutting existing residential development and road as close as possible to lowpoint at Railway crossing. • Provides collection and retardation capacity for surface water on upstream side of railway. • Created by excavation with no embankments.	• No significant remnant values.	• Suits local subcatchment drainage inflows. • Sizing sufficient to get>=70% TSS removal at outlet. • Retarding capacity allows 100 year ARI flows to be piped under railway (1650 mm nominal diameter) with flood level below existing surface. Without retardation flows would be more than doubled across the railway.	• Will abut proposed active open space. • Will provide good aesthetics to school to the south and existing residential area to the east.	• No alternative site on upstream side of the railway. • Hence this site is the only one that can guarantee a high flood protection standard for existing development abutting the railway whilst minimising pipe size under railway.
WLRB5 (Station Ck)	• Avoids land proposed for high density town centre. • Utilises land partly subject to inundation and where a minimum reserve	• No significant remnant values. Intensive market gardening lands.	• Suits local subcatchment drainage inflows. • Linear shaping reduces piping lengths. • Sizing sufficient to	• Suits current layouts. • Avoids high density land whilst creating good aesthetics along roadway.	• Could be located further downstream, at least in part, within the high density township land. • Could also be split into

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	width of 35 m would be required to provide an open waterway to convey unretarded flows. • Utilises land already partly occupied by existing large turkey-nest dam. • NTWL suits existing surface levels and allows for temporary outfall downstream if constructed in advance of high density town centre. • Created by excavation with no embankments.		get>=80% TSS removal at outlet. • Retarding capacity allows 100 year ARI flows to be piped downstream through the high density town centre (1650 mm nominal diameter).		two parts with linking pipeline. • Both options would require more expensive land take. •
WLRB6 (Station Ck)	• Utilises land partly subject to inundation and where a minimum reserve width of 35-40 m would be required. • Is the last available site before the AOS downstream. • NTWL suits existing surface levels and allows for temporary outfall downstream if constructed in advance of the waterway works around the AOS.	• No significant remnant values.	• Suits local subcatchment drainage inflows. • Sizing sufficient to get>=80% TSS removal at outlet but only 40% TN removal. • Sizing is the maximum that can be created on the site given existing levels and titles and roads. •	• Suits current layout. • Land required beyond the minimum reserve width is proposed normal density residential land rather than medium or high density. • Abuts proposed AOS. • Facilitates construction of open waterway upstream to edge of high density area and downstream along north frontage of AOS to Tuckers Road.	• No other suitable site is available.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	• Created by excavation with no embankments.				
WLRB7 (Station Ck)	• Utilises land partly subject to inundation and where a minimum reserve width of 35-40 m would be required. • Mostly created by excavation but confined by barrier fill for east-west road and high density development to the south. • Facilitates diversion of flows direct to Clyde Creek.	• No significant remnant values.	• Suits local subcatchment drainage inflows. • Sizing sufficient to get>=80% TSS removal at outlet but only 41% TN removal. • Sizing is the maximum that can be created on the site given existing levels and titles and roads. • Provides the flow capture/retardation necessary to facilitate diversion in open waterway due east to Clyde Creek. •	• Suits current development layout. • Land required beyond the minimum reserve width is proposed normal density residential land rather than higher density to the south. •	• No option to using this site if the PSP diversion alignment to Clyde Creek is to be maintained. • Additional treatment still required downstream before Clyde Creek confluence. • The option does exist to pipe some of the flows southeast through the high density land (as per current drainage alignment) to Ballarto Road to offset all impacts on Clyde Creek. • Alternatively, the outfall could be an open waterway southeast through the high density land, deleting the diversion link to Clyde Creek altogether.
WL8/BRS3 (Station Ck/Clyde Ck)	• Utilises land which is at least partly subject to inundation by Clyde Creek. • Is suited to receiving pipe inflows from land to the	• No significant remnant values. • Flanks and protects GGF 1 corridor commences just downstream.	• Suits local subcatchment drainage inflows which cannot be directly connected to Clyde Creek. • Sizing only just sufficient to get best practice	• Suits current layout and amended GGF corridor. • Generally uses land proposed for stream reserves with AOS flanking to the south.	• No other site available.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	northwest-back to Tuckers Road. • Created by excavation with no embankments. • Offline to high flows in both Station Creek and Clyde Creek.		outcomes before Clyde Creek confluence. • Does not provide significant flow retardation capacity above extended detention depth and hence not considered as a retarding storage.		
WL9/BRS4 (north tributary to Clyde Ck)	• Utilises land which is at least partly subject to inundation by Clyde Creek. • In conjunction with WL5c is the only available site to provide additional water quality treatment capacity prior to the GGF 1 corridor. • Is suited to receiving pipe inflows from land on the north side of Clyde Creek-back to Tuckers Road. • Created by excavation with no embankments. • Offline to high flows in both Station Creek and Clyde Creek.	• No significant remnant values in excavation area. • Is on the margins and partly within the amended GGF 1 corridor so values are potentially higher in future. • Sited to provide necessary buffers to existing and proposed GGF ponds.	• Suits local subcatchment drainage inflows which cannot be directly connected to Clyde Creek. • Is set offline in times of flood to Clyde Creek. • Sizing is just sufficient to maintain best practice outcomes. • Does not provide significant flow retardation capacity above extended detention depth and hence not considered as a retarding storage. • NTWL and BRS under-drainage allows treated/screened flows to be supplied to GGF ponds by gravity (valve operation). Normally all flows go to Clyde Creek.	• Suits current layout and amended GGF1 corridor. • Co-located in part with GGF1 corridor and sited to supply treated/screened water when required to support GGF ponds.	• Could be moved north (upslope) to get out of GGF 1 corridor but earthworks volumes will increase along with landtake for no significant additional benefits. •
WLRB10	• Only other site available	• No significant remnant	• Ideal location to allow	• Suits current layout.	• Could be relocated to the

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
(Clyde Ck floodplain)	along Clyde Creek inside PSP54. • Utilises land already containing an excavated dam. • Utilises land partly affected by flooding in Clyde Creek • Created by excavation with no embankments.	values in excavation area (existing dam and pine plantation). • Directly abuts the GGF 1 corridor so values are potentially higher in future. •	diversion from 40 ha Muddy Gates Creek catchment inside PSP 54 to the north. • This diversion avoids the need for temporary works east of Bells Road in PSP 55. • Sizing sufficient to comply with water quality treatment protocol at outlet to Clyde Creek.	•	north, online with the Muddy Gates Creek catchment at Bells Road. • Could then be downsized for TSS>=70% removal criteria with balance treatment downstream in WLRB16 Ext. • This would require temporary outfall in PSP 55. •
WLRB11 Ext	• Utilises land with very poor surface drainage characteristics that is also partly subject to inundation and where a minimum reserve width of 35-40 m would be required. • Created by excavation with no embankments. • Common NTWL needed throughout to comply with level constraints.	• No significant remnant values in excavation area.	• NTWL determined at 5.00 m to provide necessary invert for piped drainage systems on north side of Ballarto Road and remain >= 0.5 m above surveyed low flow water level in Clyde Creek (Western Outfall) at downstream connection point. • Offline to Clyde Creek for water quality treatment purposes. • Sizing is just sufficient to achieve water quality treatment protocol at outlet for total catchment to Clyde Creek in PSP54 and 56.	• Suits overall PSP planning but PSP 56 layout is at early stages and subject to future assessment.	• If Clyde Creek (Western Outfall) is moved eastwards then the north-south segment can be moved outside the UGZ. • NTWL's and flood levels may be slightly varied if redesign of the Clyde Creek system eventuates in conjunction with the SE WLRB. (TBA).

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
			• Flood levels are controlled by Clyde Creek hydraulics (levee-banked waterway).		
SB4 Ext	• Utilises land that is partly subject to inundation and where a minimum reserve width of 35 m would be required. • Can be created by excavation.	• TBA	• Approximate siting for preliminary design purposes only. • Levels not confirmed at this time.	• Suits overall PSP planning but PSP 56 layout is at early stages and subject to future assessment.	• Flexibility exists but to be determined later during PSP 56 assessments.
WLRB12 Ext	• Utilises land that is partly subject to inundation and where a minimum reserve width of 50 m would be required. • Utilises land abutting proposed commercial development to create a buffer to residential development. • Linear design overcomes grade limitation and includes land at the lowpoint at the future railway crossing. • Provides collection and retardation capacity for surface water on upstream side of railway. • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• Suits local subcatchment drainage (piped and open channel) inflows. • Sizing sufficient to get 76% TSS and 36% TN removal at railway outlet. • Retarding capacity allows 100 year ARI flows to be piped under railway (1800 mm nominal diameter) with flood level below existing surface. • Without retardation flows would be more than doubled across the railway. • Piping to continue through to SBRB5 Ext.	• Suits current layout by providing a buffer between industrial and residential development. • PSP 56 layout is at early stages and subject to future assessment.	• No alternative site on upstream side of the railway. • Could be further increased (longer and wider) to full wetland capacity if desired. This would also further reduce peak flows under the railway.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
SBRB5 Ext	• Utilises land that is partly subject to inundation and where a minimum reserve width of 50 m would be required. • Created by excavation with no embankments other than future Moores Road formation. • Linear design with common NTWL needed to comply with level constraints.	• No significant remnant values in excavation area (intensive market garden area)	• Sizing just sufficient to achieve best practice outcomes at Moores Road crossing. • NTWL of 9.5 m suits piping constraints under railway and provision of open waterway downstream of Moores Road.	• Suits current layout. • PSP 56 layout is at early stages and subject to future assessment.	• Could be reduced in size by adding new asset at next road crossing downstream and/or increasing WLRB13 Ext downstream.
WLRB13 Ext	• Utilises land that is currently subject to inundation from Clyde creek (Western Outfall) and local catchments. • Utilises land that is outside the UGB. • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• NTWL determined at 3.50 m to provide necessary invert for open waterway upstream and remain >= 0.5 m above surveyed low flow water level in Clyde Creek (Western Outfall) at downstream connection point. • Offline to Clyde Creek for water quality treatment purposes. • Sizing is just sufficient to achieve water quality treatment protocol at outlet for total catchment to Clyde Creek in PSP56. • Flood levels controlled by	• Suited to current layout because it is outside the UGB. • PSP 56 layout is at early stages and subject to future assessment.	• Could be relocated inside the UGB with loss of developable land.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
			levee banked Clyde Creek.		
MUDDY GATES CREEK CATCHMENT					
SBRB6a and 6b Ext	• Utilises land that is otherwise at least partly developable if not for the constraints posed by the desalination pipe. • Split into two segments by the proposed east-west roadway. • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• NTWL fixed at 15.2 m by clearance to desalination pipe. • Open waterway outfall must be provided across the desalination pipe reserve to comply with cover restrictions. • In turn this necessitates a drop structure on the west side to match the proposed open waterway. • To cross under the proposed new east-west and north-south roads the road formations will need to be raised to >= 17.0 m. • 4 no. 2.1*0.9 m RCB units required for the crossings.	• Suits current layout. • PSP 55 layout is at early stages and subject to future assessment.	• Not with current road layout and desalination pipe controls, if TSS>=70% removal criteria is retained before exit from PSP 53 into PSP 55.
SBRB7	• Utilises land in the lowest corner of PSP 54 abutting the north side of the east-west road • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• NTWL set at 15.0 m to suit inlet piping. • Outlet pipe along west side of Pound Road to connect with proposed open waterway of Muddy Gates Creek.	• Suits current layout but does occupy land that could otherwise be developed.	• Could be relocated downstream in PSP 55 at head of Muddy Gates Creek open waterway, if water quality treatment protocol further relaxed.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
WLRB14 Ext (Muddy Gates Ck)	• Located to best match very flat east-west topography along north side of Pattersons Road. • Utilises land that is partly subject to inundation and where a minimum reserve width of 40-50 m would be required. • Area is currently very poorly drained. • Created by excavation with no embankments, other than road formation.	• No significant remnant values in excavation area.	• Sizing just sufficient to achieve best practice outcomes at Pattersons Road crossing. • NTWL of 10.0 m suits inlet open waterway depth. • Temporary cleanout and deepening may be required downstream (future open waterway).	• Suits current layout as it extends across to the proposed LTC. • PSP 55 layout is at early stages and subject to future assessment.	• Could be reduced to achieve TSS>=70% removal criteria instead of best practice with balance nutrient removal achieved further downstream.
SBRB8	• Controls the whole eastern (Muddy Gates Creek) catchment of PSP54 to the Bells Road/Pattersons Road intersection lowpoint. • Split into two segments because the intersection straddles the lowpoint. • The northern segment occupies the footprint of an existing turkey nest dam. • Created by excavation with no embankments other than road formation levels (13.50+m).	• No significant remnant values.	• Suits local subcatchment drainage piped inflows. • Sizing sufficient to get>70% TSS removal at outlet. • Minor retarding capacity only-future downstream outlet will be open waterway. • Lack of existing outfall drainage capacity-temporary cleanout and deepening of open drain may be required around south side of training track establishment in southeast quadrant.	• Suits current layout.	• None available which can comply with the water quality treatment protocol. • Sediment basin must be provided before open waterway starts in PSP 55. • Could be enlarged as full wetland with additional land take in PSP 54.

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
WLRB15 Ext (Muddy Gates Ck)	• Located to best match very flat east-west topography along north side of east-west road, at tributary confluence. • Utilises land that is partly subject to inundation and where a minimum reserve width of 50 m would be required. • Area is currently very poorly drained. • Created by excavation with no embankments, other than east-west road formation.	• No significant remnant values in excavation area.	• Sizing not quite sufficient to achieve best practice outcomes at outlet. • NTWL of 8.0 m suits inlet and outlet open waterway depth. • Temporary cleanout and deepening may be required downstream (future open waterway on east side of Smiths Lane).	• Suits current layout as it extends between roads and is flanked to the south and east by AOS. • PSP 55 layout is at early stages and subject to future assessment.	• Could be reduced to achieve TSS>=70% removal criteria instead of best practice with balance nutrient removal achieved further downstream. • Could be swapped with AOS on south side of the road.
SB9 Ext	• Utilises land that is otherwise at least partly developable if not for the constraints posed by the desalination pipe. • Created by excavation with no embankments.	• No significant remnant values in excavation area.	• NTWL will be fixed by clearance to desalination pipe (no data available but likely about 1 m below existing surface). • Open waterway outfall must be provided across the desalination pipe reserve to comply with cover restrictions. • In turn this will likely necessitate a drop structure on the west side to match the proposed open waterway.	• Suits current layout. • PSP 55 layout is at early stages and subject to future assessment.	• Not with current road layout and desalination pipe controls. • Catchment area is already too large to move the asset downstream even if as-built data on the desalination pipe does confirm this is feasible in terms of levels. •

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive
(Ext-signifies asset is located outside the PSP53 and 54 boundaries)

Asset on Figure 4	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
			• Multiple shallow RCB units will be required for any road or trail crossing in the Pound Road reserve.		
WLRB16 Ext (Muddy Gates Ck)	• Located to best match very flat east-west topography along north side of Ballarto Road • Utilises land that is partly subject to inundation and where a minimum reserve width of 60 m would be required. • Linear extension to the east allows connection of tributary without additional crossing of Ballarto Road. • Area is currently very poorly drained. • Created by excavation with no embankments, other than Ballarto Road formation.	• High remnant flora values recently identified in excavation area.	• Sizing just sufficient to comply with water quality treatment protocol at Ballarto Road UGB boundary. • NTWL of 5.0 m suits future inlet and outlet open waterway depth. • Temporary cleanout and deepening may be required downstream (future open waterway on south side of Ballarto Road)	• Suits current layout as it creates an extended buffer to Ballarto Road and the area outside the UGB to the south. • PSP 55 layout is at early stages and subject to future assessment.	• Could be reduced to achieve TSS>=70% removal criteria instead of best practice with balance nutrient removal achieved further downstream in the future SEWLRB. • Could be swapped entirely into land outside the UGB on south side of Ballarto Road. • Could be reshaped-realigned to suit retention of flora values if required.
CARDINIA CREEK CATCHMENT					
Baillieu Creek WL1	• Located to best match topography adjacent to PSP boundary • Arranged to use transmission land as far as	• No significant environmental values. • Cultural/heritage values now confirmed as not significant constraints.	• Sizing complies with water quality treatment protocol at PSP 53 boundary. • NTWL of 23.0 m suits	• Suits current layout but requires extended waterway reserve frontage along road to existing outfall drain at Smiths	• Could be reduced to achieve TSS>=70% removal criteria with balance nutrient removal achieved downstream in

TABLE 3 ASSET SITING AND DESIGN CONSIDERATIONS AND OPTIONS-refer to Figures 4-7 inclusive (Ext-signifies asset is located outside the PSP53 and 54 boundaries)					
Asset on Figure 4	**Topography Considerations**	**Environmental/Cultural Heritage Considerations**	**Drainage Level/Flow/Quality Control Considerations**	**PSP/Development Layout Considerations**	**Any other option?**
	practicable.		future inlet piping and outlet open waterway depth (PSP55). • Temporary cleanout and deepening may be required downstream of Smiths Lane (future open waterway). • Not modelled as retarding storage at this time but final design should maximise retardation capacity values in airspace.	Lane. • Final reserve layout may be varied to better suit future development in PSP 55. • PSP 55 layout is at early stages and subject to future assessment.	PSP 55, if protocol relaxed.

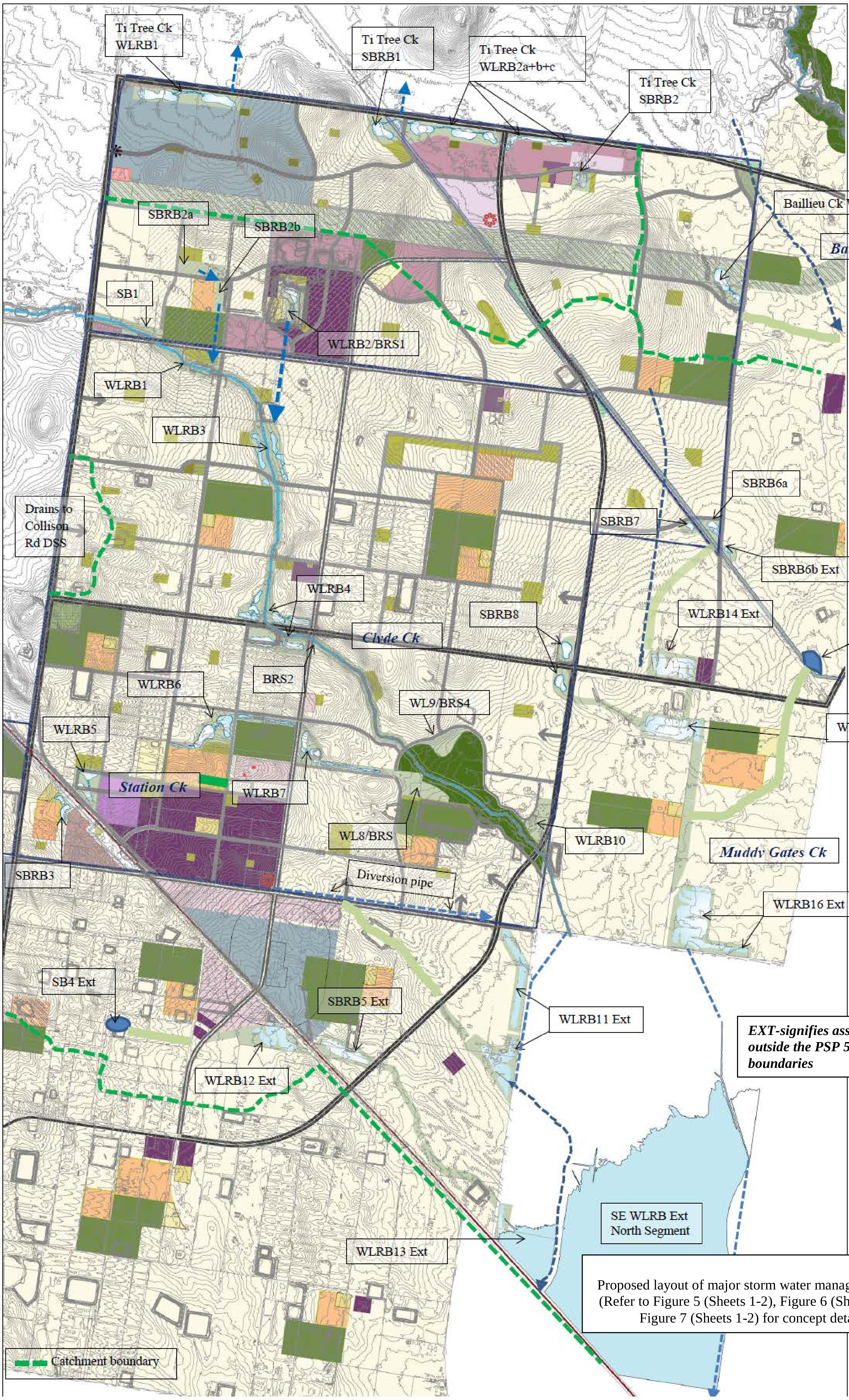


Figure 4
Proposed layout of major storm water management assets (Refer to Figure 5 (Sheets 1-2), Figure 6 (Sheets 1-6) and Figure 7 (Sheets 1-2) for concept details of assets)

6. RORB RESULTS FOR DEVELOPED CONDITIONS

6.1 Parameter Values

6.1.1 Clyde Creek/Muddy Gates Creek Catchment

The model structure changes from the original SE WLRB version have significantly changed $d_{av,}$ (average flow length for all subareas with respect to the model outlet) and it is necessary to adjust K_c to ensure the relative storage for each reach remains the same.

For existing conditions K_c = 13.00, m = 0.8, with d_{av} = 5.50 km. Hence K_c/D_{av} = 2.36.

For the developed conditions model in its final version, d_{av} = 6.52 km, so K_c = 15.41.

6.1.2 Ti Tree Creek Catchment

There was no significant change to d_{av} so K_c remained at 11.00, m =0.80.

6.2 Stage-Storage-Discharge Relations

The MUSIC model V3 was used to determine water surface areas for each asset, according to the water quality treatment protocol set out in Section 4.2 and as varied in Section 4.3. Those results are listed in Table 4. 1.

Concept layouts for the primary assets are shown overlaid on the 0.5 m LiDAR survey data on Figure 5 (Sheets 1-2), Figure 6 (Sheets 1-6), and Figure 7 (Sheets 1-2).

Normal Top Water Levels (NTWL's) were selected from the 0.5 m LiDAR data having regard to constraints posed by planning layout, protection of identified habitat areas, likely pipe gradings and sizes, and desirable open waterway grades.

Stage-area-storage relations listed in the RORB datafiles (**PSP53 54 and SE WLRB NMC Dec 13.cat; Titrult10.cat)** are derived from those concept layouts.

Stage-discharge relations for each retarding storage were derived by trial and error running of the model using a standard 3-weir control system. Low level extended detention storage control was set at NTWL with weir crest lengths of between 0.1 and 0.6 m depending on catchment size. The next weir was set at top of extended detention depth (generally NTWL+0.5 m). That weir crest length was varied until discharge matched the desired peak outflow or 100 year ARI water level had reached the maximum practicable level for the site. Spillway crest level was set just above the 100 year ARI flood level. Adopted hydraulic controls for all retarding storage assets are summarised in Table 4.1.

For the storages in the existing floodplain of Clyde Creek downstream of Ballarto Road (WLRB11 Ext and WLRB13 Ext), the stage-storage-discharge relations were derived following the hydraulic analysis of the outfall system as described in Section 8.

This work established that hydraulic characteristics of the levee-banked outfall channel controlled outflows from the proposed storages and hence for large flood events the storages are effectively online to Clyde Creek.

To reflect the fact that water quality treatment areas are to be maintained offline to the major flood flows (at least until all velocity criteria are complied with), the stage-storage relations were modified to exclude the extended detention storage volumes. The stage-storage-discharge relations for WLRB11 Ext and WLRB13 Ext are listed in Table 4.2.

TABLE 4.1 Proposed Main SWMS Assets in the CGA
(PSP 53 and 54 and related catchments)
(*-incl creek reserve)

Waterway	Asset/Location	Inside PSP	Water Surface Area (ha)	NTWL (m)	Approx. Site Area (ha) *	Adopted Weir Controls for RB's (Crest Level/width for Weir 1 Crest Level/width for Weir 2 Crest Level/width for Weir 3)
Ti Tree Ck (Port Phillip Bay)	WLRB1	53	4.00	23.50	6.80	23.7/0.2, 24.2/1.0, 25.75/20
	SBRB1	53	1.10	25.20	2.34	25.2/0.2, 25.7/2.0, 26.3/20
	WLRB2a	53	2.55	23.70	6.02	23.7/0.2, 24.2/0.9, 26.3/20
	WLRB2b	53	0.28	23.70	1.93	
	WLRB2c	53	0.22	23.70		
	SBRB2	53	0.45	24.00	1.41	24.0/0.1, 24.5/0.2, 26.5/20
	Totals		8.60		18.50	
Baillieu Ck (Cardinia Ck)	WL1a	53	1.33	23.00	3.8 (TE)	
	WL1b	53	0.42	23.00	1.70	
	WL1c	53	0.20	23.00		
	Totals		1.95		5.50	
Clyde Creek	SB1	53	0.05	26.50	0.60 *	
	WLRB1	54	2.00	26.00	4.20 *	26.0/0.5, 26.5/3, 28.3/20
	SBRB2a	53	0.20	27.80	0.85	27.8/0.2, 28.3/1.0, 29.5/20
	SBRB2b	53	0.35	27.80	1.25	
	WLRB2/BRS1	53	1.92	27.20	4.00	27.2/0.2, 27.7/0.6, 29.7/20
	WLRB3	54	3.90	24.00	6.60 *	24.0/0.3, 24.5/4, 26.5/30
	WLRB4	54	5.90	21.00	11.50 *	21.0/0.6, 21.5/4.5, 23.0/20
	BRS2	54	0.12	20.80 (FS)	0.48 *	
Station Creek	SBRB3	54	0.35	30.00	1.10	30.0/0.2, 30.5/0.9, 32.5/20
	WLRB5	54	1.20	29.50	3.20	29.5/0.3, 30.0/3.0, 31.0/20
	WLRB6	54	1.90	24.00	4.10 *	24.0/0.3, 24.5/2.5, 26.0/20,
	WLRB7	54	1.40	20.00	2.80 *	19.0/0.3, 20.0/5, 21.25/10
	WL8	54	1.20	14.50	3.15	

TABLE 4.1 Proposed Main SWMS Assets in the CGA (PSP 53 and 54 and related catchments) (*-incl creek reserve)

Waterway	Asset/Location	Inside PSP	Water Surface Area (ha)	NTWL (m)	Approx. Site Area (ha) *	Adopted Weir Controls for RB's (Crest Level/width for Weir 1 Crest Level/width for Weir 2 Crest Level/width for Weir 3)
	BRS3		0.06	14.45		
North Tributary	WL9	54	1.50	15.00	3.50	
	BRS4	54	0.03	14.90		
Bells Rd	WLRB10	54	0.80	10.00	2.70	10.0/0.15, 10.5/0.6, 11.5/20
Clyde Creek (currently Western Contour Drain)	WLRB11 Ext	56	6.00	5.00	11.00	
	SB4 Ext	56	0.35	TBA	0.85 TBC	
	WLRB12 Ext	56	2.00	11.50	4.20	11.5/0.3, 12.0/3.0, 13.2/20
	SBRB5 Ext	56	1.20	9.50	3.20	9.5/0.3, 10.0/5, 11.0/20
	WLRB13 Ext		5.00	3.50	9.00	
	Totals		37.43		77.98	
Muddy Gates Creek (currently Muddy Gates Drain)	SBRB6a	53	0.50	15.20	1.10	15.2/0.5, 15.7/5, 16.5/20
	SBRB6b Ext	55	0.25	15.20	0.75	15.2/0.6, 15.7/10, 16.3/20
	SBRB7	54	0.20	15.00	0.90	15.2/0.3, 15.7/2, 16.5/20
	WLRB14 Ext	55	2.80	10.00	4.80	10.0/0.5, 10.5/5, 11.5/30
	SBRB8	54	1.70	12.50	3.50	12.5/0.3, 12.8/6, 13.75/30
	WLRB15 Ext	55	3.70	8.00	6.00	8.0/0.6, 8.5/6, 9.75/30
	SB9 Ext	55	0.50	12.00 TBC	1.10 TBC	
	WLRB16 Ext	55	8.00	5.00	11.90	5.0/0.6, 5.5/25, 6.35/50
	Totals		17.65		30.05	
	Overall Totals		65.63		132.03	

TABLE 4.2 Stage-storage-discharge relations for WLRB11 Ext and WLRB13 Ext (derived from Clyde Creek hydraulic analyses in Appendix A and excluding extended detention volumes)

Asset	Stage (m AHD)	Storage (m3)	Discharge (m3/s)
WLRB11 Ext	4.00	0	0
		10	0.5
		20	1.0
		30	2.5
	5.04	50	5.0
		75	7.5
	5.45	100	10.0
	5.61	6,000	12.5
	5.76	20,000	15.0
	6.00	39,150	21.0
	6.10	48,000	26.0
	6.50	87,000	30.0
	7.00	100,000	60.0
WLRB13 Ext8	2.60	0	0
	2.90	10	0.1
	3.10	20	0.2
	3.40	30	0.3
	3.75	60	0.5

TABLE 4.2 Stage-storage-discharge relations for WLRB11 Ext and WLRB13 Ext (derived from Clyde Creek hydraulic analyses in Appendix A and excluding extended detention volumes)			
Asset	**Stage (m AHD)**	**Storage (m3)**	**Discharge (m3/s)**
	4.00	290	1.5
	4.21	5,600	3.4
	4.37	10,500	8.2
	4.50	15,870	13.8
	4.69	27,100	24.0
	4.73	29,000	25.2
	4.85	35,000	29.0
	5.00	44,000	45.0
	5.20	60,000	70.0

6.3 RORB Model Results

Table 5 summarises the model results for 1, 10, and 100 years ARI conditions. In all cases the model was run with filtered temporal patterns ON, uniform areal pattern ON and Siriwardena and Weinmann Areal Reduction Factor ON. No results are listed for assets not modelled as retarding storages.

TABLE 5 RORB Model Results for fully developed conditions Waterway and storage layout as shown on Figure 4 (Critical Durations in parentheses) (Models: PSP53 54 and SE WLRB NMC Dec 13.cat; Titrult10.cat)						
ARI (yrs)	**Creek**	**Asset/Location**	**Peak Inflow (m3/s)**	**Peak Outflow (m3/s)**	**Water Level (m)**	**Storage Volume (m3)**
1	Ti Tree	WLRB1	5.1 (2)	0.8 (48)	24.63	41,900
		SBRB1	3.8 (2)	0.7 (36)	25.98	10,500
		SBRB2	1.6 (2)	0.2 (30)	24.81	4,560
		WLRB2a+b+c	4.3 (2)	1.0 (36)	24.68	36,400
	Clyde	SBRB2a+b	2.6 (2)	0.4 (36)	28.52	6,030
		WLRB1	4.2 (25m)	2.9 (48)	27.04	24,000
		WLRB2 (Quarry)	5.2 (2)	0.7 (48)	28.22	24,200
		WLRB3	5.0 (2)	3.7 (48)	25.08	48,200
		WLRB4	5.7 (2)	3.6 (48)	21.98	66,900
	Station	SBRB3	2.8 (2)	0.9 (9)	31.02	4,740
		WLRB5	3.4 (2)	1.2 (36)	30.30	14,900
		WLRB6	3.0 (2)	1.6 (36)	24.91	20,800
		WLRB7	1.8 (36)	1.5 (36)	20.19	21,500
	Clyde	Clyde Creek at GGF 1		4.3 (48)		
		WLRB10	1.0 (2)	0.2 (48)	10.66	5,800
		Clyde Creek at Ballarto Rd		4.3 (48)		
		WLRB11 Ext	9.1 (1.5)	8.9 (1.5)	5.36 *	893 *
		WLRB12 Ext	2.8 (2)	1.4 (48)	12.34	19,300
		SBRB5 Ext	3.4 (2)	1.8 (36)	10.31	11,500
		WLRB13 Ext	5.5 (36)	5.4 (36)	4.28 *	7,620 *
		Clyde Creek at Railway		5.4 (36)		
	Muddy Gates	SBRB6a	2.4 (2)	1.3 (9)	15.91	3,900
		SBRB6b Ext	1.9 (9)	1.8 (9)	15.87	1,930

TABLE 5 RORB Model Results for fully developed conditions
Waterway and storage layout as shown on Figure 4 (Critical Durations in parentheses)
(Models: PSP53 54 and SE WLRB NMC Dec 13.cat; Titrult10.cat)

ARI (yrs)	Creek	Asset/Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Water Level (m)	Storage Volume (m3)
		SBRB7	1.0 (2)	0.4 (9)	15.82	1,460
		Muddy Gates Ck at Pound Rd		2.2 (9)		
		WLR14 Ext	2.8 (9)	1.8 (48)	10.74	23,800
		SBRB8	4.2 (1)	2.1 (9)	13.12	11,700
		WLRB15 Ext	3.4 (48)	3.0 (48)	8.86	34,500
		Pound Rd south		2.6 (2)		
		WLRB16 Ext	4.9 (48)	4.4 (30)	5.70	59,100
		Muddy Gates Creek at Ballarto Rd		4.4 (48)		
		Muddy Gates Creek at Railway		4.6 (48)		
10	Ti Tree	WLRB1	9.6 (2)	1.7 (48)	24.98	61,700
		SBRB1	7.9 (2)	2.0 (9)	26.24	15,600
		SBRB2	3.2 (25m)	0.5 (9)	25.12	6,910
		WLRB2a+b+c	8.2 (2)	2.1 (48)	25.08	54,400
	Clyde	SBRB2a+b	5.2 (2)	0.9 (9)	28.78	10,200
		WLRB1	9.0 (25m)	6.1 (48)	27.44	35,700
		WLRB2 (Quarry)	11.1 (2)	1.5 (12)	28.60	36,600
		WLRB3	11.5 (2)	7.7 (24)	25.49	69,900
		WLRB4	12.5 (2)	8.1 (36)	22.39	103,000
	Station	SBRB3	6.1 (2)	1.9 (9)	31.40	7,580
		WLRB5	7.3 (2)	3.0 (9)	30.61	22,000
		WLRB6	5.8 (2)	3.2 (9)	25.20	29,600
		WLRB7	3.6 (12)	3.3 (12)	20.43	26,700
	Clyde	Clyde Creek at GGF 1		10.3 (48)		
		WLRB10	2.5 (2)	0.5 (12)	10.90	8,330
		Clyde Creek at Ballarto Rd		10.5 (48)		
		WLRB11 Ext	18.2 (1.5)	11.6 (2)	5.55 *	3,770 *
		WLRB12 Ext	6.7 (2)	3.5 (9)	12.67	28,900
		SBRB5 Ext	6.2 (2)	4.3 (9)	10.57	16,400
		WLRB13 Ext	12.4 (48)	12.4 (48)	4.47 *	14,500 *
		Clyde Creek at Railway		12.4 (48)		
		SBRB6a	5.6 (2)	3.2 (4.5)	16.14	5,350
	Muddy Gates	SBRB6b Ext	4.6 (4.5)	4.3 (4.5)	16.05	2,540
		SBRB7	2.4 (2)	1.0 (4.5)	16.03	2,090
		Muddy Gates Ck at Pound Rd		5.6 (4.5)		
		WLR14 Ext	6.5 (9)	4.8 (9)	11.08	34,300
		SBRB8	10.2 (2)	4.4 (9)	13.34	16,800
		WLRB15 Ext	9.1 (9)	7.0 (9)	9.18	49,500
		Pound Rd south		6.2 (2)		
		WLRB16 Ext	11.8 (12)	10.6 (12)	5.87	75,000
		Muddy Gates Creek at Ballarto Rd		10.6 (12)		
		Muddy Gates Creek at Railway		10.9 (12)		
100	Ti Tree	WLRB1	16.5 (2)	3.2 (12)	25.45	90,100
		SBRB1	14.5 (25m)	4.3 (9)	26.42	19,400
		SBRB2	6.3 (15 m)	0.7 (9)	25.59	11,200
		WLRB2a+b+c	14.6 (25m)	3.8 (12)	25.57	83,500
	Clyde	SBRB2a+b	10.8 (15m)	1.7 (9)	29.09	15,900
		WLRB1	16.8 (15m)	11.4 (24)	27.96	51,400
		WLRB2 (Quarry)	21.0 (25m)	2.8 (12)	29.20	56,200
		WLRB3	22.6 (25m)	14.8 (24)	26.06	102,000

TABLE 5 RORB Model Results for fully developed conditions
Waterway and storage layout as shown on Figure 4 (Critical Durations in parentheses)
(Models: PSP53 54 and SE WLRB NMC Dec 13.cat; Titrult10.cat)

ARI (yrs)	Creek	Asset/Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Water Level (m)	Storage Volume (m3)
		WLRB4	26.4 (25m)	15.7 (24)	22.92	150,000
	Station	SBRB3	11.7 (20m)	3.7 (4.5)	31.97	11,800
		WLRB5	13.9 (2)	5.7 (9)	30.96	31,300
		WLRB6	10.6 (2)	6.5 (9)	25.67	44,600
		WLRB7	7.0 (9)	6.5 (12)	21.18	45,400
	Clyde	Clyde Creek at GGF 1		20.4 (36)		
		WLRB10	4.8 (20m)	1.0 (9)	11.25	12,700
		Clyde Creek at Ballarto Rd		20.8 (30)		
		WLRB11 Ext	33.7 (25m)	22.8 (48)	6.04 *	42,400 *
		WLRB12 Ext	13.3 (2)	6.5 (9)	13.04	40,100
		SBRB5 Ext	11.6 (20m)	8.0 (9)	10.89	24,000
		WLRB13 Ext	25.4 (48)	25.2 (48)	4.76 *	29,000 *
		Clyde Creek at Railway		25.2 (48)		
		SBRB6a	11.0 (2)	7.6 (2)	16.48	7,960
	Muddy Gates	SBRB6b Ext	10.5 (2)	10.3 (2)	16.31	3,590
		SBRB7	4.5 (20m)	2.3 (1)	16.33	3,130
		Muddy Gates Ck at Pound Rd		12.7 (2)		
		WLR14 Ext	12.4 (2)	9.1 (9)	11.43	48,000
		SBRB8	20.3 (2)	8.5 (4.5)	13.64	24,500
		WLRB15 Ext	17.9 (9)	15.0 (9)	9.66	74,100
		Pound Rd south		12.2 (2)		
		WLRB16 Ext	23.4 (9)	22.1 (9)	6.12	97,900
		Muddy Gates Creek at Ballarto Rd		22.1 (9)		
		Muddy Gates Creek at Railway		25.2 (12)		

**** Storage volumes for assets WLRB11 Ext and WLRB13 Ext along the current Western Contour Drain exclude extended detention storage volumes. Flood levels accord with hydraulic analysis.***

6.4 Comparison with Existing Conditions

Table 6 presents a comparison of the fully developed peak flows (FD) with those for existing conditions.

TABLE 6 Peak Discharges for varying ARI (m3/s)
(Critical durations in parentheses)

Waterway	Location	1 yr ARI		10 yr ARI		100 yr ARI	
		Exist	FD	Exist	FD	Exist	FD
Ti Tree Creek	Thompsons Rd West		0.8 (48)		1.7 (48)	6.0 (9)	3.2 (12)
	Thompsons Rd East		1.0 (36)		2.1 (48)	6.1 (9)	3.8 (12)
Clyde Creek	Hardys Road	2.5 (36)	2.7 (36)	5.3 (36)	5.6 (48)	10.1 (30)	10.7 (24)
	Tuckers Road	2.8 (48)	3.2 (48)	7.2 (48)	7.7 (36)	17.4 (30)	15.2 (24)
	Ballarto Road	2.6 (48)	3.7 (48)	7.1 (36)	9.4 (36)	16.2 (30)	20.3 (30)
Clyde Creek (Western Contour Drain)	Confluence d/s Ballarto Road	2.9 (48)	4.3 (48)	8.8 (36)	10.9 (48)	21.0 (30)	22.8 (30)
	Railway	3.2 (48)	5.6 (48)	10.5 (36)	13.1 (48)	25.7 (30)	22.8 (30)
Muddy Gates Drain	Pattersons Road	0.6 (36)	1.8 (48)	1.8 (9)	4.8 (9)	4.9 (12)	9.1 (9)
	Ballarto Road	1.8 (36)	4.4 (30)	6.1 (9)	10.7 (12)	16.5 (12)	23.6 (9)
	Confluence d/s Ballarto Road	2.0 (36)	4.5 (30	6.7 (9)	10.8 (12)	18.0 (24)	24.0 (9)
	Railway	2.0 (48)	4.6 (30)	6.8 (24)	10.9 (12)	18.1 (24)	25.2 (12)

For the Ti Tree Creek outfalls the results show significant reductions in peak 100 year ARI discharge for fully developed conditions. This indicates that the water surface areas and depths below surface levels provided in the concept designs, to comply with water quality treatment and pipe drainage outfall requirements, create flood storage capacities well in excess of those required to comply with flow retardation limits.

This is a beneficial outcome for the connections from Thompsons Road to Ti Tree Creek. The western outfall peak flow of 3.2 m^3/s can be contained in a 1500 mm diameter pipe through the Clyde North PSP developments.

For the eastern connection the flow reduction allows a 1650 mm diameter pipe to be used across Thompsons Road. The final design of this outfall and the ultimate 100 year ARI flood level will be dependent on detail design of the flood storage system on the north side of Thompsons Road.

Regardless of the final design flood level the minimum finished surface level on the south side of Thompsons Road should be 26.50 m to retain a safety margin over the level of Thompsons Road (26.30 m).

For the Western Port outfalls the results show:

- a trend of minor but still significant increases in peak discharge at most locations for all ARI's along Clyde Creek, (except downstream of Tuckers Road to Station Creek confluence where 100 year ARI flows are reduced);

- significant increases in peak discharge for all ARI's along Muddy Gates Creek.

The Clyde Creek discharge increases should not be of concern for the GGF 1 corridor reach given that all the upstream waterways will be stable. Waterway design, construction and vegetation must all accord with MW's best practice guidelines.

The impacts in Clyde Creek at Tuckers Road are then largely offset by the network of retarding storages. The fact that peak flows are increased again downstream is due to the diversion of all flows in Station Creek across and into Clyde Creek from WLRB7 to WL8. Station Creek naturally drains southeast to Ballarto Road and joins the Western Contour Drain further downstream.

If considered necessary, it would be feasible to mitigate the impacts in the GGF 1 reach if some flows in Station Creek (say above the 3 months ARI peak up to 2 m^3/s maximum) were continued (in a pipe) southeast through the high density and medium density residential areas and thence to Ballarto Road, separate from the GGF1 reach of Clyde Creek. The open waterway of Station Creek from Tuckers Road eastwards to Clyde Creek would be retained for the more frequently occurring flows and flows in excess of the pipe capacity. WL8/BRS3 would still perform the water quality treatment function for Station Creek flows.

The Muddy Gates Creek discharge increases are of no concern through to the SE WLRB as the open waterway systems can easily be designed to cope with the higher flows.

The SE WLRB will be designed to eliminate impacts altogether at the Railway line for both Clyde Creek and Muddy Gates Creek, and to provide increased protection from flooding to rural lands downstream, compared with existing conditions.

6.5 Preliminary Sizing of Major Drainage Conduits

From the RORB results listed in Table 5, preliminary sizings of the main drainage conduits discharging from the retarding storages and under main road crossings have been estimated to assist with DSS preparation. These are summarised in Table 7. It should be noted that detail design may be expected to result in different conduit arrangements to suit service or geotechnical constraints.

TABLE 7 Preliminary Sizing of Major Drainage Conduits

Creek	Asset	100 yr ARI peak discharge (m3/s)	Conduit Sizing (mm)	Road/Segment
Ti Tree Creek	WLRB1	3.2	1500 Ø	Thompsons Rd
	SBRB1	4.3	3*1200*450 RCB	Pound Rd/Desal Resersve
	SBRB2	0.7	1050 Ø	SBRB2-WLRB2c
	WLRB2a+b+c	3.8	900 Ø	WLRB2b-2c
			1650 Ø	Thompsons Rd
Clyde Creek	SBRB2a+b	1.7	1200 Ø	SBRB2a-2b-WLRB1
	WLRB1	11.4	2* 2100 Ø	Hardys Rd and Un-named Nth-Sth Rd
	WLRB2 (Quarry)	2.8	1500 Ø	WLRB2-WLRB3
	WLRB3	14.8	2* 2100 Ø	Un-named East-West Rd
	WLRB4	15.7	3* 2100 Ø	Pattersons Rd
			2* 2100 Ø	Tuckers Rd
Station Creek	SBRB3	3.7	1650 Ø	Railway and Twyford Road
	WLRB5	5.7	1650 Ø	Un-named Nth-South Rd
	WLRB6	6.5	2* 1500 Ø	Un-named Nth-South Rd
	WLRB7	6.5	na	Open waterway
Bells Rd	WLRB10	1.0	900 Ø	WLRB10-Bells Rd bridge
Clyde Creek	Ballarto Rd	20.8	na	Existing bridge
	WLRB11 Ext		1800 Ø (w) 1500 Ø (e)	Ballarto Rd Inlets
		22.8	na	Clyde Creek outlet control
Moores Rd/Railway tributary	WLRB12 Ext	6.5	1800 Ø	WLRB12 Ext-SBRB5
	SBRB5 Ext	8.0	1950 Ø	Moores Rd
Clyde Creek	WLRB13 Ext	25.2	na	Clyde Creek
	Railway	25.2	na	Existing bridge
Muddy Gates Creek	SBRB6a	7.6	4*2100*900 RCB	Smiths Lane-un-named east-west Rd
	SBRB6b Ext	10.3	4*2100*900 RCB	Pound Rd-desal reserve-Smiths Lane
	SBRB7	2.3	1200 Ø	SBRB7-Muddy Gates Ck
	WLR14 Ext	9.1	2* 1800 Ø	Pattersons Rd
	SBRB8	8.5	2* 2100 Ø	Pattersons Rd
			3* 1350 Ø	Bells Rd
	WLRB15 Ext	15.0	2* 2100 Ø	Smiths Lane
	SB9 Ext	12.2	TBA	Pound Rd-desal reserve
	WLRB16 Ext	22.1	6*2400*900 RCB	Ballarto Rd
	Railway	25.2	na	Existing bridge

7. WATER QUALITY MODELLING

The proposed stormwater drainage system was modelled for full development conditions, using MUSIC Version 3 with the 6 minute rainfall data sequence for Koo Wee Rup, 2004 as required by MW (***Filenames: PSP 53 and 54 V4 Dec 13 KWR 2004 6 min and Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min***).

The model structures for the Ti Tree Creek and Clyde Creek/Muddy Gates Creek catchments are shown diagrammatically on Figures 8 and 9.

The results in Table 8 summarise the system performance at critical locations in Ti Tree Creek, Clyde Creek, Muddy Gates Creek, and Baillieu Creek, and in the main tributaries.

Table 9 lists load removals in individual assets.

The results confirm that the key water quality treatment protocols are satisfied.

Mean annual flow volumes into and out of each asset are listed and can be used as inputs into the water reuse study being carried out by SEW.

TABLE 8 MUSIC Model Results
(PSP 53 and 54 V4 Dec 13 KWR 2004 6 min)
(Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)

Location/Asset/Parameter	Catchment Source Loads	Residual Loads	% Load removal in system to asset outlet
TI TREE CREEK CATCHMENT			
WLRB1			
Flow (ML/yr)	954	916	4
Suspended Solids (Kg/yr)	186,000	26,800	86
Total Phosphorus (Kg/yr)	381	105	73
Total Nitrogen (Kg/yr)	2,690	1,430	47
Gross Pollutants (kg/yr)	32,300	0	100
WLRB2a+b+c (incl SBRB1 and SBRB2)			
Flow (ML/yr)	1,230	1,180	4
Suspended Solids (Kg/yr)	244,000	25,700	90
Total Phosphorus (Kg/yr)	503	121	76
Total Nitrogen (Kg/yr)	3,500	1,770	50
Gross Pollutants (kg/yr)	43,400	0	100
CLYDE CREEK CATCHMENT			
Cascades on Clyde WLRB (Clyde Ck)			
Flow (ML/yr)	3,610	3,530	2
Suspended Solids (Kg/yr)	674,000	208,000	69
Total Phosphorus (Kg/yr)	1,410	600	57
Total Nitrogen (Kg/yr)	10,210	6,580	35

TABLE 8 MUSIC Model Results (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Location/Asset/Parameter	**Catchment Source Loads**	**Residual Loads**	**% Load removal in system to asset outlet**
Gross Pollutants (kg/yr)	123,000	364	100
WLRB1 (Clyde Ck)			
Flow (ML/yr)	4,250	4,130	3
Suspended Solids (Kg/yr)	797,000	232,000	71
Total Phosphorus (Kg/yr)	1,660	709	57
Total Nitrogen (Kg/yr)	12,000	7,650	36
Gross Pollutants (kg/yr)	145,000	0	100
WLRB2/BRS1 (MTC)			
Flow (ML/yr)	762	739	3
Suspended Solids (Kg/yr)	152,000	27,900	82
Total Phosphorus (Kg/yr)	313	93	70
Total Nitrogen (Kg/yr)	2,220	1,200	46
Gross Pollutants (kg/yr)	27,000	0	100
WLRB3 (Clyde Ck)			
Flow (ML/yr)	5,830	5,640	3
Suspended Solids (Kg/yr)	1,110,000	283,000	75
Total Phosphorus (Kg/yr)	2,300	909	61
Total Nitrogen (Kg/yr)	16,500	10,200	38
Gross Pollutants (kg/yr)	201,000	0	100
WLRB4/BRS2 (Clyde Ck)			
Flow (ML/yr)	6,760	6,490	4
Suspended Solids (Kg/yr)	1,290,000	241,000	81
Total Phosphorus (Kg/yr)	2,670	862	68
Total Nitrogen (Kg/yr)	19,100	9,940	48
Gross Pollutants (kg/yr)	233,000	0	100
Station Creek tributary (WL8/BRS3)			
Flow (ML/yr)	1,780	1,700	4
Suspended Solids (Kg/yr)	345,000	67,700	80
Total Phosphorus (Kg/yr)	712	226	68
Total Nitrogen (Kg/yr)	5,110	2,750	46
Gross Pollutants (kg/yr)	62,500	358	99
Clyde Creek d/s Station Ck			
Flow (ML/yr)	8,890	8,530	4
Suspended Solids (Kg/yr)	1,700,000	318,000	81
Total Phosphorus (Kg/yr)	3,530	1,120	68
Total Nitrogen (Kg/yr)	25,200	13,100	48
Gross Pollutants (kg/yr)	308,000	547	100
Clyde Creek @ Ballarto Rd			
Flow (ML/yr)	9,090	8,720	4
Suspended Solids (Kg/yr)	1,730,000	326,000	81
Total Phosphorus (Kg/yr)	3,600	1,140	68

TABLE 8 MUSIC Model Results (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Location/Asset/Parameter	**Catchment Source Loads**	**Residual Loads**	**% Load removal in system to asset outlet**
Total Nitrogen (Kg/yr)	25,800	13,400	48
Gross Pollutants (kg/yr)	315,000	547	100
Clyde Creek @ WLRB11 Ext Confluence			
Flow (ML/yr)	10,700	10,200	4
Suspended Solids (Kg/yr)	2,040,000	376,000	82
Total Phosphorus (Kg/yr)	4,230	1,320	69
Total Nitrogen (Kg/yr)	30,300	15,700	48
Gross Pollutants (kg/yr)	371,000	547	100
Railway/Moores Rd tributary@			
Flow (ML/yr)	1,730	1,640	5
Suspended Solids (Kg/yr)	333,000	37,600	89
Total Phosphorus (Kg/yr)	690	180	74
Total Nitrogen (Kg/yr)	4,980	2,570	49
Gross Pollutants (kg/yr)	60,800	0	100
Clyde Creek @ Railway			
Flow (ML/yr)	12,400	11,900	4
Suspended Solids (Kg/yr)	2,380,000	414,000	83
Total Phosphorus (Kg/yr)	4,920	1,500	70
Total Nitrogen (Kg/yr)	35,300	18,300	48
Gross Pollutants (kg/yr)	432,000	547	100
MUDDY GATES CREEK CATCHMENT			
Muddy Gates Creek d/s Pound Rd			
Flow (ML/yr)	802	794	1
Suspended Solids (Kg/yr)	152,000	39,700	74
Total Phosphorus (Kg/yr)	323	149	54
Total Nitrogen (Kg/yr)	2,280	1,710	25
Gross Pollutants (kg/yr)	28,100	0	100
Muddy Gates Creek @ Pattersons Rd			
Flow (ML/yr)	1,170	1,120	4
Suspended Solids (Kg/yr)	222,000	31,500	86
Total Phosphorus (Kg/yr)	469	132	72
Total Nitrogen (Kg/yr)	3,320	1,830	45
Gross Pollutants (kg/yr)	40,800	0	100
Bells Rd/Pattersons Rd PSP 54 outfall			
Flow (ML/yr)	906	893	1
Suspended Solids (Kg/yr)	174,000	36,900	79
Total Phosphorus (Kg/yr)	356	152	57
Total Nitrogen (Kg/yr)	2,600	1,830	30
Gross Pollutants (kg/yr)	31,800	0	100
Chasemore Rd Tributary (Desal crossing)			
Flow (ML/yr)	533	529	1

TABLE 8 MUSIC Model Results (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Location/Asset/Parameter	**Catchment Source Loads**	**Residual Loads**	**% Load removal in system to asset outlet**
Suspended Solids (Kg/yr)	98,300	27,900	72
Total Phosphorus (Kg/yr)	207	100	52
Total Nitrogen (Kg/yr)	1,490	1,150	23
Gross Pollutants (kg/yr)	18,700	0	100
Muddy Gates Creek @ Ballarto Rd			
Flow (ML/yr)	4,350	4,160	5
Suspended Solids (Kg/yr)	817,000	95,200	88
Total Phosphorus (Kg/yr)	1,710	439	74
Total Nitrogen (Kg/yr)	12,300	6,380	48
Gross Pollutants (kg/yr)	146,000	0	100
CARDINIA CREEK CATCHMENT			
Baillieu Creek @ PSP 53 boundary			
Flow (ML/yr)	375	354	6
Suspended Solids (Kg/yr)	71,300	12,300	83
Total Phosphorus (Kg/yr)	149	46	69
Total Nitrogen (Kg/yr)	1,070	539	50
Gross Pollutants (kg/yr)	12,300	0	100

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
TI TREE CREEK CATCHMENT			
WLRB1			
Flow (ML/yr)	954	916	38
Suspended Solids (Kg/yr)	186,000	26,800	159,200
Total Phosphorus (Kg/yr)	381	105	276
Total Nitrogen (Kg/yr)	2,690	1,430	1,260
Gross Pollutants (kg/yr)	32,300	0	32,300
SBRB1			
Flow (ML/yr)	485	477	8
Suspended Solids (Kg/yr)	95,500	15,800	79,700
Total Phosphorus (Kg/yr)	196	74	122
Total Nitrogen (Kg/yr)	1,380	898	482
Gross Pollutants (kg/yr)	17,000	0	17,000
SBRB2			
Flow (ML/yr)	174	171	3
Suspended Solids (Kg/yr)	34,700	4,810	2,989
Total Phosphorus (Kg/yr)	71	25	46
Total Nitrogen (Kg/yr)	489	307	182
Gross Pollutants (kg/yr)	6,160	0	6,160

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
WLRB2a+b+c			
Flow (ML/yr)	1,220	1,180	40
Suspended Solids (Kg/yr)	134,000	25,700	108,300
Total Phosphorus (Kg/yr)	335	121	214
Total Nitrogen (Kg/yr)	2,840	1,770	1,070
Gross Pollutants (kg/yr)	20,200	0	20,200
CLYDE CREEK CATCHMENT			
SB1			
Flow (ML/yr)	50	49	1
Suspended Solids (Kg/yr)	9,610	3,060	6,550
Total Phosphorus (Kg/yr)	20	10	10
Total Nitrogen (Kg/yr)	144	109	35
Gross Pollutants (kg/yr)	1,750	0	1,750
SBRB2a+b			
Flow (ML/yr)	293	289	1
Suspended Solids (Kg/yr)	58,500	11,600	46,900
Total Phosphorus (Kg/yr)	122	49	73
Total Nitrogen (Kg/yr)	829	579	250
Gross Pollutants (kg/yr)	10,300	0	10,300
WLRB1 (Clyde Ck)			
Flow (ML/yr)	4,160	4,130	30
Suspended Solids (Kg/yr)	278,000	232,000	46,000
Total Phosphorus (Kg/yr)	777	709	68
Total Nitrogen (Kg/yr)	8,100	7,650	450
Gross Pollutants (kg/yr)	10,200	0	10,200
WLRB2/BRS1 (MTC)			
Flow (ML/yr)	762	739	23
Suspended Solids (Kg/yr)	152,000	27,800	124,200
Total Phosphorus (Kg/yr)	313	92	221
Total Nitrogen (Kg/yr)	2,220	1,200	1,020
Gross Pollutants (kg/yr)	27,000	0	27,000
WLRB3 (Clyde Ck)			
Flow (ML/yr)	5,690	5,640	50
Suspended Solids (Kg/yr)	416,000	283,000	133,000
Total Phosphorus (Kg/yr)	1,130	908	222
Total Nitrogen (Kg/yr)	11,100	10,200	900
Gross Pollutants (kg/yr)	28,600	0	28,600
WLRB4 (Clyde Ck)			
Flow (ML/yr)	6,560	6,490	50
Suspended Solids (Kg/yr)	462,000	269,000	193,000
Total Phosphorus (Kg/yr)	1,280	940	340
Total Nitrogen (Kg/yr)	12,800	11,200	1,600
Gross Pollutants (kg/yr)	32,300	0	32,300

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
BRS2 (Clyde Ck)			
Flow (ML/yr)	6,490	6,490	70
Suspended Solids (Kg/yr)	269,000	241,000	28,000
Total Phosphorus (Kg/yr)	940	862	78
Total Nitrogen (Kg/yr)	11,200	9,940	1,260
Gross Pollutants (kg/yr)	0	0	0
SBRB3 (Railway)			
Flow (ML/yr)	386	384	2
Suspended Solids (Kg/yr)	75,500	23,200	52,300
Total Phosphorus (Kg/yr)	155	77	78
Total Nitrogen (Kg/yr)	1,100	847	253
Gross Pollutants (kg/yr)	13,400	0	13,400
WLRB5			
Flow (ML/yr)	826	807	19
Suspended Solids (Kg/yr)	108,000	42,600	65,400
Total Phosphorus (Kg/yr)	252	132	120
Total Nitrogen (Kg/yr)	2,140	1,520	620
Gross Pollutants (kg/yr)	15,700	0	15,700
WLRB6			
Flow (ML/yr)	1,250	1,220	30
Suspended Solids (Kg/yr)	125,000	58,100	66,900
Total Phosphorus (Kg/yr)	306	192	114
Total Nitrogen (Kg/yr)	2,780	2,270	510
Gross Pollutants (kg/yr)	15,500	0	15,500
WLRB7			
Flow (ML/yr)	1,400	1,390	10
Suspended Solids (Kg/yr)	92,900	58,500	34,400
Total Phosphorus (Kg/yr)	265	204	61
Total Nitrogen (Kg/yr)	2,800	2,480	320
Gross Pollutants (kg/yr)	6,280	0	6,280
WL8			
Flow (ML/yr)	1,720	1,700	20
Suspended Solids (Kg/yr)	125,000	84,800	40,200
Total Phosphorus (Kg/yr)	338	272	66
Total Nitrogen (Kg/yr)	3,420	3,130	290
Gross Pollutants (kg/yr)	11,700	391	11,309
BRS3			
Flow (ML/yr)	1700	1,700	0
Suspended Solids (Kg/yr)	84,800	67,700	17,100
Total Phosphorus (Kg/yr)	272	226	46
Total Nitrogen (Kg/yr)	3,130	2,750	380
Gross Pollutants (kg/yr)	391	358	33

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
WL9 (Clyde Ck)			
Flow (ML/yr)	353	335	18
Suspended Solids (Kg/yr)	66,700	13,600	53,100
Total Phosphorus (Kg/yr)	140	45	95
Total Nitrogen (Kg/yr)	1,010	522	498
Gross Pollutants (kg/yr)	12,400	203	12,197
BRS4			
Flow (ML/yr)	335	335	0
Suspended Solids (Kg/yr)	13,600	9,350	4,250
Total Phosphorus (Kg/yr)	45	33	12
Total Nitrogen (Kg/yr)	522	388	134
Gross Pollutants (kg/yr)	203	189	14
WLRB10			
Flow (ML/yr)	199	190	9
Suspended Solids (Kg/yr)	37,300	7,240	30,060
Total Phosphorus (Kg/yr)	76	23	53
Total Nitrogen (Kg/yr)	566	297	269
Gross Pollutants (kg/yr)	6,980	0	6,980
WLRB11 Ext			
Flow (ML/yr)	1,570	1,510	60
Suspended Solids (Kg/yr)	310,000	50,700	259,300
Total Phosphorus (Kg/yr)	630	177	453
Total Nitrogen (Kg/yr)	4,530	2,350	2,180
Gross Pollutants (kg/yr)	55,700	0	55,700
SB4 Ext			
Flow (ML/yr)	374	371	3
Suspended Solids (Kg/yr)	70,100	20,500	49,600
Total Phosphorus (Kg/yr)	145	71	74
Total Nitrogen (Kg/yr)	1,050	814	236
Gross Pollutants (kg/yr)	13,200	0	13,200
WLRB12 Ext			
Flow (ML/yr)	971	950	21
Suspended Solids (Kg/yr)	137,000	45,600	91,400
Total Phosphorus (Kg/yr)	314	147	167
Total Nitrogen (Kg/yr)	2,580	1,790	790
Gross Pollutants (kg/yr)	21,200	0	21,200
SBRB5 Ext			
Flow (ML/yr)	1,360	1,350	10
Suspended Solids (Kg/yr)	127,000	46,500	80,500
Total Phosphorus (Kg/yr)	313	212	101
Total Nitrogen (Kg/yr)	2,950	2,550	400
Gross Pollutants (kg/yr)	14,500	0	14,500
WLRB13 Ext			

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
Flow (ML/yr)	1,700	1,640	60
Suspended Solids (Kg/yr)	111,000	37,600	739400
Total Phosphorus (Kg/yr)	348	180	169
Total Nitrogen (Kg/yr)	3,560	2,570	990
Gross Pollutants (kg/yr)	12,000	0	12,000
MUDDY GATES CREEK CATCHMENT			
SBRB6a			
Flow (ML/yr)	463	459	4
Suspended Solids (Kg/yr)	87,700	23,400	64,300
Total Phosphorus (Kg/yr)	189	88	101
Total Nitrogen (Kg/yr)	1,320	995	325
Gross Pollutants (kg/yr)	16,200	0	16,200
SBRB6b Ext			
Flow (ML/yr)	184	182	2
Suspended Solids (Kg/yr)	34,400	8,650	25,750
Total Phosphorus (Kg/yr)	72	33	39
Total Nitrogen (Kg/yr)	524	390	134
Gross Pollutants (kg/yr)	6,460	0	6,460
SBRB7			
Flow (ML/yr)	154	153	1
Suspended Solids (Kg/yr)	30,200	7,720	22,480
Total Phosphorus (Kg/yr)	63	29	34
Total Nitrogen (Kg/yr)	433	324	109
Gross Pollutants (kg/yr)	5,410	0	5,410
WLRB14 Ext			
Flow (ML/yr)	1,160	1,120	40
Suspended Solids (Kg/yr)	110,000	31,500	78,500
Total Phosphorus (Kg/yr)	294	132	62
Total Nitrogen (Kg/yr)	2,750	1,830	920
Gross Pollutants (kg/yr)	12,700	0	12,700
SBRB8			
Flow (ML/yr)	906	893	15
Suspended Solids (Kg/yr)	174,000	36,900	137,100
Total Phosphorus (Kg/yr)	356	152	204
Total Nitrogen (Kg/yr)	2,600	1,830	770
Gross Pollutants (kg/yr)	31,800	0	31,800
WLRB15 Ext			
Flow (ML/yr)	2,530	2,490	40
Suspended Solids (Kg/yr)	169,000	74,600	94,400
Total Phosphorus (Kg/yr)	490	310	180
Total Nitrogen (Kg/yr)	5,110	4,180	930
Gross Pollutants (kg/yr)	18,000	0	18,000
SB9 Ext			

TABLE 9 MUSIC Model Results for Individual Assets (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min) (Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min)			
Asset/Parameter	**Input Loads**	**Residual Loads**	**Load removal in asset**
Flow (ML/yr)	533	529	4
Suspended Solids (Kg/yr)	98,300	27,900	70,400
Total Phosphorus (Kg/yr)	207	100	107
Total Nitrogen (Kg/yr)	1,490	1,150	340
Gross Pollutants (kg/yr)	18,700	0	18,700
WLRB16 Ext			
Flow (ML/yr)	4,250	4,160	90
Suspended Solids (Kg/yr)	325,000	95,200	229,800
Total Phosphorus (Kg/yr)	881	439	442
Total Nitrogen (Kg/yr)	8,800	6,380	2,420
Gross Pollutants (kg/yr)	36,300	0	36,300
CARDINIA CREEK CATCHMENT			
WL1 (Baillieu Ck)			
Flow (ML/yr)	375	354	21
Suspended Solids (Kg/yr)	71,300	12,300	59,000
Total Phosphorus (Kg/yr)	149	46	103
Total Nitrogen (Kg/yr)	1,070	539	531
Gross Pollutants (kg/yr)	12,300	0	12,300

8. THE SE WLRB DESIGN CONCEPT

8.1 Hydraulic Modelling

As part of this current investigation MW has commissioned detail cross-sectional survey of both major outfalls south of Ballarto Road to the Bay, including details of all private and public crossings. The field survey was generally limited to the waterway environs within the reserves.

This information was imported into a HEC-RAS one dimensional hydraulic model, with roughness parameters and energy contraction/expansion coefficients selected to accord with conditions depicted in the extensive survey photo library, backed up by field inspections.

Along the Clyde Creek outfall the field survey cross-sections were extended out westwards from the waterway reserve using the LiDAR data so as to ensure simulations of overbank flow conditions were reliable. The limit of the LiDAR data provided is about 1 km downstream of Manks Road which was sufficient to provide good accuracy for water levels calculated around Manks Road and upstream.

Tailwater levels at the Bay end of the outfalls were determined using the information contained in the CSIRO June 2008 report[4] on climate change impacts on extreme sea levels in the Western Port Region. Trial runs demonstrated that tidal levels do not play a significant role in determining major flood levels in the subject area.

The hydraulic models were then used to determine water surface profiles along the outfall alignments for varying flows, so as to highlight critical capacity constraints and flood levels for existing conditions.

Full details can be found in Appendix A.

8.1.1 Hydraulic Capacity of Clyde Creek

The HEC-RAS analysis has determined that:

- The constructed waterway with its east side levee bank has sufficient capacity to convey the 100 year ARI discharges (refer Table 1 Appendix A) under existing conditions to south of Manks Road.

[4] Effect of Climate Change on Extreme Sea Levels in the Western Port Region, Prepared by: *Kathleen L. McInnes, Ian Macadam, Julian O'Grady,* CSIRO Marine and Atmospheric Research, June 2008

- In the 100 year ARI event freeboard is virtually exhausted just upstream of the Railway.

- The eastern levee bank currently prevents overtopping in the 100 year ARI event and protects land to the east as was the original design intent.

- By preventing breakaway flows going east the levee bank thereby increases flood levels on land along the western verge of the waterway. Large areas of land are inundated inside the UGB boundary (north of XS 50) and near the Railway.

- Velocities of flow in the main channel zone average about 0.5 m/s in the 1 year ARI event, rising to about 1 m/s in the 100 year ARI event. Locally higher velocities to 1.5 m/s occur around constrictions including bridges and farm crossings.

8.1.2 Hydraulic Capacity of Muddy Gates Creek

The HEC-RAS analysis has determined that:

- The constructed waterway has sufficient capacity to convey less than the 10 year ARI discharges (refer Table 1 Appendix A) under existing conditions around XS 45 and between XS 47 and XS 51 along Muddy Gates Lane. Critical capacity is about 5 m^3/s. Overflows in these locations must then disperse south-easterly into the Koo Wee Rup Flood Protection District (KFPD).

- The constructed waterway has sufficient capacity to just convey the 10 year ARI discharges along the balance of Muddy Gates Lane frontage to McAlpine Road;

- Downstream of the jumble of constrictions imposed by McAlpine Road, the Railway and the two Manks Road crossings, the levee banked channel generally has capacity at or marginally greater than 10 years ARI. It should be noted that prior to the major cleanout works that were completed after the floods in 2011, capacity would have been significantly less.

- Due to very flat grades there is no prospect of significant increase in outfall capacity for Muddy Gates Drain without major widening of the constructed waterway downstream of Manks Road and probably upgrade of the bridges at Manks Road/Railway/McAlpine Road.

- Velocities of flow in the main channel zone average less than 0.5 m/s in the 1 year ARI event, rising to about 0.6-0.7 m/s at overtopping capacity. Locally higher velocities to less than 1 m/s occur around constrictions including bridges and farm crossings.

8.1.3 Implications for UGB Development Strategy

8.1.3.1 Clyde Creek Corridor

1. 100 year ARI flood extents shown on Figure A.2 verify that the site recommended for WLRB11 Ext is subject to inundation by Clyde Creek (and local tributary runoff) under existing conditions. Inundation occurs for flows>15 m^3/s at XS 52.

2. The extent of inundation in this area is largely driven by the flat topography but depth is increased by the levee bank confinement. Realignment of Clyde Creek further east would allow the depth and extent of inundation of land within the UGB to be reduced.

3. 100 year ARI flood extents shown on Figure A.2 verify that the site recommended for WLRB13 Ext (on the east side of the UGB boundary) and parts of neighbouring titles, are already subject to flooding.

4. Cross-sectional plots on Figure A.6 show that the site for WLRB13 Ext is mostly inundated for flows >7 m^3/s which is about 5 years ARI under existing conditions. As there is no prospect of flooding of this land being mitigated it is recommended that this site be confirmed for stormwater management purposes.

5. Between the WLRB11 Ext and WLRB13 Ext sites, a high spur of land more than 15 ha in area sits well above 100 year ARI flood levels. This land is outside the UGB but contiguous with elevated land to the west.

6. The 100 year ARI flood extents shown on Figure A.2 also show that two other large areas between Manks Road and the Railway are extensively inundated west of the Clyde Creek alignment. These areas are ideal for future wetland development as was highlighted in a previous study for MW in 2010. Further assessment of this potential is beyond the scope of this current investigation.

7. Future peak flows in Clyde Creek in the vicinity of the Railway crossing need to be reduced compared with existing conditions to restore acceptable freeboard to the railway and main levee (crest level 5.2 m AHD). The trial flows assessment indicates a peak 100 year ARI flow passing through the Railway bridge should not exceed ~21 m^3/s to restore freeboard to about 0.5 m.

8. Short of further increases in land take within development areas to expand flood storage capacity, the only option available to reduce peak flows in Clyde Creek is to divert some flows eastwards into the proposed SE WLRB, and the most suitable location for this is from opposite the WLRB13 Ext site or close by.

8.1.3.2 Muddy Gates Creek Corridor

1. Peak 100 year ARI flows in Muddy Gates Creek would need to be restricted at or preferably upstream of Muddy Gates Lane to 5 m^3/s, and at the Railway to about 10 m^3/s, in order to fully protect lands downstream in the KFPD.

2. Under existing conditions the peak 100 year ARI flow passing Ballarto Road is 18 m^3/s, which is far in excess of available capacity downstream.

3. The current proposed strategy for management of runoff in the CGA in Muddy Gates Creek catchment cannot reduce future peak flow flows below about 24 m^3/s at Ballarto Road as listed in Table 6.

4. Consequently unless there is further significant land take within the CGA there is no feasible option to providing a major flood storage basin south of Ballarto Road, primarily to control discharges in the Muddy Gates Creek catchment.

5. It makes sense to design such a flood storage to incorporate water quality treatment for both the Clyde Creek and Muddy Gates Creek catchments.

6. It makes further sense to optimise the design of such a flood storage to maximise flood protection benefits to the east of the existing outfall system in the KWFPD.

8.2 Form of the SE WLRB

A preliminary concept for the SE WLRB was developed in an initial study for MW in 2010. It was based on using land below the 5 m AHD contour between Clyde Creek and Muddy Gates Creek south of Ballarto Road to Manks Road, in two segments north and south of the railway line. This study extends the work done in 2010 but is focussed on determining functional design requirements of the northern segment only.

The majority of the flood storage must be used to control discharges in Muddy Gates Creek. Clyde Creek inflows need only be restricted to those required to achieve water quality treatment objectives and to restore suitable freeboard at the railway in the 100 year ARI flood event.

All flows entering the north segment of the SE WLRB must be discharged back into Muddy Gates Creek at the railway under gravity flow control. Higher flood levels in Clyde Creek prevent outflow to that waterway.

Although both the Clyde Creek and Muddy Gates Creek outfalls are artificial in origin, some significant aquatic and ephemeral habitat values are likely to have evolved over the years, predominantly downstream of Lynes Road in the tidal zones. Maintenance and protection of these values will be dependent to a large degree on continuation of reasonable freshwater low flows.

For Clyde Creek, additional freshwater supply will be provided via development south of the railway line so it should only be necessary to maintain small passing flows at the Railway which is in close proximity to the likely SE WLRB offtake structure. No such potential exists for Muddy Gates Creek however reinjection of flows at the railway at the SE WLRB outlet increases overall volumes and frequency of runoff events.

For present purposes it has been assumed that all flows up to 0.2 m^3/s in Clyde Creek and 0.3 m^3/s in Muddy Gates Creek will be passed downstream along existing alignments before any flows are diverted into the SE WLRB (Note: this assumption may be reviewed and adjusted during detail design). Hence any proposals for reuse of surface water in the SE WLRB will be limited to capture and diversion of higher flows.

Figure 10 illustrates the conceptual hydraulic management arrangement proposed for the SE WLRB.

Unlike conventional constructed urban wetland systems the concept envisages that the SE WLRB will be largely ephemeral in nature beyond a permanent pond zone. This is partly a response to the massive size of the potential wetland area and cost of excavation to form permanent wetlands. However it more directly responds to a desire to recreate a wetland swamp community approximating the original Great Swamp. It is acknowledged that the SE WLRB site may have actually been part of the Clyde Grasslands which bordered the swamp, however, by manipulating the longer term hydrologic regime as proposed, the conditions necessary to support intended vegetation communities should be fostered.

Inflows from Clyde Creek and Muddy Gates Creek are proposed to be dispersed via low height contour berms across the maximum possible vegetated area. The concept on Figure 10 implies a series of ~0.3 m berms between the 3.0 and 4.0 m contours. The area affected by flow dispersal should be revegetated at a density appropriate to result in a recreation of a melaleuca/carex swamp community over the longer term. Expert advice would be obtained to complete detail design of the system.

8.3 RORB Model Adjustments

The model was adjusted to reflect the outcomes of the lower waterway hydraulic analyses as follows:

8.3.1 Clyde Creek

- Both WLRB11 Ext and WLRB13 Ext were adjusted to be online with the Clyde Creek waterway rather than offline as was previously setup in the V2 November 2012 report.

- The WLRB11 Ext hydraulic controls were amended to mimic the stage-discharge relation derived from the hydraulic analysis.

- The WLRB11 Ext stage-storage relation was amended to exclude the extended detention storage volume (as this will remain effectively offline to main creek flows).

- The WLRB13 Ext hydraulic controls were amended to mimic the stage-discharge relation derived from the hydraulic analysis at the railway.

- The WLRB13 Ext stage-storage relation was amended to exclude the extended detention storage volume (as this will remain effectively offline to main creek flows).

(Note: the results listed in Tables 5 and 6 incorporate these amendments).

The model was then run in trial and error mode to determine the required peak flow diversion across to the SE WLRB, in order to achieve the desired flood level just upstream of the Railway bridge.

It was found that diverting all flows in excess of the 0.2 m^3/s low flow protection limit up to a maximum of 4 m^3/s, would just satisfy the criteria, producing a 100 year ARI flood level of 4.73 m.

The conceptual arrangement for control of flows at the railway inlet adopts the following controls:

- 600 mm diameter control pipe in existing creek invert (3.0 m).
- 35 m wide overflow weir just downstream in Clyde Creek at sill level of 4.2 m.
- 6 m wide outlet weir to the SE WLRB outlet culvert on the left bank at sill level of 3.8 m.
- Culvert orifice control through the main levee bank, limiting discharge to SE WLRB to 4 m^3/s at the 100 year ARI flood level.

A spillway crest should also be provided in the levee bank above the 100 year ARI flood level. This is to safely pass events larger than 100 years ARI into the SE WLRB so as to maximise protection for the Railway bridge.

8.3.2 Muddy Gates Creek

At the upstream offtake diversion point (Cross-section 53), the diversion works are assumed to be designed to achieve the following flow splits:

Approach Flow in Muddy Gates Creek from Ballarto Road (m3/s)	**Flow diverted into SE WLRB (m3/s)**	**Flow to Muddy Gates Creek at Muddy Gates Lane (m3/s)**
0	0	0
0.3	0	0.3
1.0	0.7	0.3
7.5	4.0	3.5
15.0	10.5	4.5
30.0	25.0	5.0

8.3.3 SE WLRB Stage-Storage-Discharge

The WLRB is assumed to have a permanent pond created by excavation to function as a water reuse pondage.

The pond size may vary depending on the results of the SEW reuse study but the minimum size would be fixed by the volume of fill material needed to create the necessary confining embankments along Muddy Gates Lane and the Railway.

For current purposes it is assumed that excavation will create up to 25 ha water surface area at NTWL of 3.0 m AHD, with 50,000 m^3 volume (dead storage).

For the confining bank alignments shown on Figure 10, the adopted stage-storage relation is as follows:

TABLE 10 SE WLRB Stage-Storage

Stage (m)	Area (m2)	Active Storage (m3)	Discharge Controls
3.0	250,000	0	0.5 m weir
3.5	425,000	168,750	5.0 m weir
4.0	1,191,500	572,875	
4.2	1,360,000	850,000	Free discharge starts around north end of levee
4.5	1,600,000	1,270,750	

The discharge controls were adopted after trial and error runs with the RORB model to best match a desirable 100 year ARI flood level of 4.20 m in the storage with total peak discharge in Muddy Gates Creek at the Railway bridge less than 10 m^3/s.

8.4 RORB Model Results

The model runs produced the following results.

TABLE 11 RORB Model Results for fully developed conditions
Waterway and storage layout as shown on Figure 4 (Critical Durations in parentheses)
(Model: PSP53 54 and SE WLRB NMC Dec 13.cat)

ARI (yrs)	Creek	Asset/Location	Peak Inflow (m3/s)	Peak Outflow (m3/s)	Water Level (m)	Storage Volume (m3)
100	Clyde	Clyde Creek at Ballarto Rd		20.3 (30)		
		WLRB11 Ext online	33.7 (15)	22.8 (48)	6.04	42,400 *
		WLRB13 Ext	25.4 (2)	25.2 (48)	4.73	29,000 *
		Outflow to SE WLRB		4.0 (48)		
		Clyde Creek at Railway		21.2 (48)		
	Muddy Gates	Muddy Gates Creek at Ballarto Rd		22.1 (9)	6.12	97,900
		Flow passing along Muddy Gates Drain		5.0 (9)		
		Outflow to SE WLRB		18.0 (9)		
		SE WLRB	25.7 (72)	6.7 (72)	4.19	835,000
		Muddy Gates Creek at Railway		9.5 (48)		

Thus the concept layout shown on Figure 10 satisfactorily achieves the critical flood management objectives for both Clyde Creek and Muddy Gates Creek:

- Peak 100 year ARI outflows in Clyde Creek at the Railway are 21.2 m^3/s with flood level of 4.73 m (west side of levee).

- Peak 100 year ARI flows in Muddy Gates Creek at Muddy Gates Lane and at the Railway of 5 and 9.5 m^3/s respectively, which provides 100 year ARI flood protection to lands east of Muddy Gates Lane in the KFPD.

- Peak 100 year ARI flood level in the SE WLRB of 4.19 m which infers the maximum embankment crest level need be no higher than 4.50 m. Curtailing the bank at surface level of 4.20 m provides spillway capacity at the north end on Muddy Gates Lane. The full bank height should be continued along the railway frontage.

8.5 Water Quality Modelling

The MUSIC model was adjusted to incorporate the flow diversion protocols for both Clyde Creek and Muddy Gates Creek and rerun to confirm likely water quality treatment outcomes.

The design intent is for the ephemeral wetland system within the SE WLRB to increase water quality treatment outcomes for the Western Port outfalls as close to SEPP F8 limits as practicable, assuming zero reuse of stormwater across the CGA.

Tables 12, 13 and 14 summarise the overall load outcomes and treatment effectiveness.

Table 14 shows that the overall SWMS incorporating the SE WLRB easily exceeds the SEPP F8 objectives for the combined Clyde Creek and Muddy Gates Creek outfalls at the Railway. This assumes no reuse at all of stormwater supply across the catchment so the outcome is guaranteed.

The results can also be interpreted as showing that the current concept “over treats” Clyde Creek flows at the expense of Muddy Gates Creek flows. Given the close proximity of the outfalls to each other this would not appear to be of any concern for Western Port Bay environments. However if there are any concerns raised by others in regard to local impacts at Muddy Gates Creek outlet to Western Port Bay this can easily be corrected during detail design by increasing the minor flow bypass along Clyde Creek and reducing minor flow bypass at the Muddy Gates Creek offtake. Reduction in low flow bypass in Muddy Gates Creek only affects the short length along Muddy Gates Lane north of the Railway.

Such changes, if deemed necessary, will shift the water quality treatment focus more towards Muddy Gates Creek without altering the overall outcomes for flood mitigation or SEPP F8 standards.

Optimising design of inlets and outlets to the SE WLRB is a task that can be completed as part of detail design at a future time.

TABLE 12 Summary MUSIC Model Results for Clyde Creek and Muddy Gates Creek (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min)

Location/Parameter	Total Source Loads	Residual Loads	Load removal in CGA	% Source Load Removal	Load To SE WLRB	Load To Outfall	Effective Load Removal from Outfall	% Source Load Removal from Outfall
Clyde Ck @ SE WLRB offtake								
Flow (ML/yr)	12,400	11,900	500	4	5,630	6,270	6,130	49
Suspended Solids (Kg/yr)	2,380,000	414,000	1,966,000	83	203,000	211,000	2,169,000	91
Total Phosphorus (Kg/yr)	4,920	1,500	3,420	70	769	731	4,189	85
Total Nitrogen (Kg/yr)	35,300	18,300	17,000	48	9,580	8,720	26,580	75
Gross Pollutants (kg/yr)	432,000	547	431,453	~100	223	324	431,676	~100
Muddy Gates Ck @ Ballarto Road								
Flow (ML/yr)	4,350	4,160	200	4				
Suspended Solids (Kg/yr)	817,000	95,200	722,000	88				
Total Phosphorus (Kg/yr)	1,710	439	1,272	74				
Total Nitrogen (Kg/yr)	12,300	6,380	5,960	48				
Gross Pollutants (kg/yr)	146,000	0	146,000	100				
Muddy Gates Ck @ SE WLRB Offtake								
Flow (ML/yr)	4,600	4,400			1,060	3,340		
Suspended Solids (Kg/yr)	850,000	128,000			61,700	66,300		
Total Phosphorus (Kg/yr)	1,790	518			198	320		
Total Nitrogen (Kg/yr)	13,000	7,040			2,290	4,750		
Gross Pollutants (kg/yr)	146,000	928			285	643		

TABLE 13 Summary MUSIC Model Results for SE WLRB (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min)

Parameter	**Input from Clyde Ck**	**Input from Muddy Gates Ck**	**Local Rural Source Loads**	**Total Input Load to SE WLRB**	**Total Load removed (zero reuse)**	**% Load Removal**	**Discharge to Muddy Gates Ck**	**Total in Muddy Gates Ck @ Railway**
Flow (ML/yr)	5,630	1,060	678	7,368	1,038	14	6,330	9,670
Suspended Solids (Kg/yr)	203,000	61,700	95,200	359,900	305,100	85	54,800	121,100
Total Phosphorus (Kg/yr)	769	198	224	1,191	757	64	434	754
Total Nitrogen (Kg/yr)	9,580	2,290	1,760	13,630	6,480	48	7,150	11,900
Gross Pollutants (kg/yr)	223	285	2,570	3,078	3,078	100	0	643

TABLE 14 MUSIC Model Results for Total System @Railway Outfalls (PSP 53 and 54 V4 Dec 13 KWR 2004 6 min)

Parameter	**Clyde Ck CGA Source Loads**	**Muddy Gates Ck CGA Source Loads**	**Total CGA Source Loads to Bay Outfalls**	**Residual Loads to Clyde Ck Outfall**	**SE WLRB Discharge to Muddy Gates Ck Outfall**	**Bypass of SE WLRB in Muddy Gates Ck**	**Total Discharge to Outfalls**	**Total Loads Removed in SWMS**	**% removal of CGA Source Loads**
Flow (ML/yr)	12,400	4,350	**16,750**	2,490	6,330	3,340	**12,160**	4,590	27
Suspended Solids (Kg/yr)	2,380,000	817,000	**3,197,000**	74,600	54,800	66,300	**195,700**	3,001,300	94
Total Phosphorus (Kg/yr)	4,920	1,710	**6,630**	310	434	320	**1,064**	5,566	84
Total Nitrogen (Kg/yr)	35,300	12,300	**47,600**	4,180	7,150	4,750	**16,080**	31,520	66
Gross Pollutants (kg/yr)	432,000	146,000	**578,000**	0	0	643	**643**	577,357	~100

9. STAGING/IMPLEMENTATION CONSIDERATIONS

9.1 General Principles

The number and location of the stormwater management assets across the PSP areas has been arranged to minimise overall capital expenditure and ongoing costs, and to utilise as much land which is already encumbered by flooding as is practicable (rather than otherwise developable land), having regard to other constraints such as flora/fauna values, main roads, railway, development proposals, and the desalination pipeline.

It is possible to split SBRB's or WLRB's into segments to better suit staged or "out-of-sequence" development, or to resolve property ownership demarcations. However there is an "efficiency" penalty in doing this. As storage depths are basically fixed by flood levels and creek levels, and batter lengths are increased, splitting storages directly increases land area requirements. Other studies indicate storage capacity requirements rise by about 20% on average when a WLRB is split into two segments.

Similarly there is a penalty for ongoing operation and maintenance costs with increased numbers and total areas of assets.

Subject to suitable arrangements being put in place to cover any capital cost or ongoing cost penalties and the same performance standards being met, there is no technical reason why a storage cannot be split to better suit development layouts or land ownership differences.

It is standard practice in urban development contributory drainage schemes across the greater Melbourne area, for any temporary management facilities that may be required to service "out-of-sequence" development (as may be required to protect downstream undeveloped land and/or the environment) to be funded by the proponents of that development without reimbursement from the scheme.

Timing of construction of SBRB's and WLRB's (and connecting pipelines or waterways) is entirely governed by the progress, rate and staging of development. The need for, and extent/size of any temporary management facilities that may be required to service "out-of-sequence" development is similarly affected.

Subject to MW and Council agreement (as the ongoing responsible bodies for operation and maintenance), flexibility should always be retained to allow different landowners to negotiate changes to drainage layout and design of assets-with any extra capital costs outside the DSS also being negotiated between them.

9.2 Development Application Requirements and Compliance

Applications for development approval for lands within the PSP areas may include construction of permanent works included in the Clyde Creek DS, or temporary works to adequately service "out-of-sequence" developments or to defer major works expenditure downstream.

The following principles will be applied by MW and Council in responding to all applications:

- Temporary works do not form part of the CCDS and hence are to be fully funded by the development proponent, unless they are part of ultimate drainage design works (eg., partial excavation of a larger SBRB or waterway or wetland that are to be funded as part of the DS).

- Development proponents are required to show in any application how the development proposal affects, or is affected by the requirements of the PSP SWMS.

- Development proponents must provide Stormwater Environmental Management Plans (SEMP) which identify potential waterway stability/environmental/drainage/flooding problems and constraints arising from their development proposals (including upstream or downstream impacts on existing receiving environments, waterways, land uses and assets/works), and quantify and recommend what is required to ensure compliance with best practice water management objectives.

- Unless otherwise pre-approved by MW and Council, temporary works are not to be designed in a manner which prevents free invert drainage and/or which causes under-design surcharging for any permanent pipeline system (eg., a 5 year ARI capacity pipeline being surcharged in lesser storm events because of outfall capacity restrictions). Every SEMP must include computations verifying compliance with this requirement.

- Every SEMP must deal explicitly with control over stormwater sediment loads and monitoring of same during estate construction works, and demonstrate how the works comply with best practice whilst addressing high construction-era sediment loads, potential acid sulphate soils and dispersive soils management issues.

- Potential acid sulphate soils and dispersive soils management issues are to be identified and appraised by suitably qualified geotechnical personnel.

- Where the proposed development drainage management measures do not form part of the DS schedule, the development proponents are required to investigate, design, construct and fund all costs of establishment of the temporary works, including monitoring and reporting of water quality testing as may be required by MW, Council, or DEPI, and ongoing maintenance requirements and costs.

- Statements of compliance will be conditional, in part, on cleanout and resetting of sediment management assets before handover to MW/Council for ongoing responsibility, and on satisfactory financial arrangements being reached with MW/Council for ongoing maintenance and eventual reclamation of temporary works.

9.3 Default Deemed to Comply Solution for Temporary Drainage

A temporary drainage solution has been developed in accordance with a modified version of MW’s standard conditions for localised intensive development proposals in the KooWeeRup Flood Protection District (KWRFPD). This solution will be deemed to comply with all requirements without specific hydrologic and water quality design computations.

By way of background, the drainage system in the KWRFPD cannot accept any increase in stormwater flows resulting from intensive development, such as poultry farms. All such developments must therefore incorporate an on-site stormwater retention dam that controls runoff from only the impervious surfaces within the development. The requirements of this detention are:

- 900m^3 of freeboard storage in a dam above full supply level per hectare of catchment area (and including the dam area in this);

- Freeboard storage to be no more than 450mm deep;

- Outlet from the dam to be controlled to 3 1/s per hectare of catchment (including dam area again); and

- The dam should be lined with an impervious lining and the freeboard provision should be above the natural surface to avoid possible groundwater problems.

The Clyde Creek and Muddy Gates catchments drain via the Western Contour Drain and Muddy Gates Drain to Western Port and are outside the KWRFPD. Whilst the sloping lands in these catchments are mostly moderately to well-drained, lower lying areas around drainage lines still experience drainage problems under existing rural land use and waterlogging of lower lying flat lands is an issue in normal winter/spring seasons. This is especially the case in Muddy Gates Drain beyond the PSP 53 and 54 boundaries but is also of significance along Clyde Creek and tributaries. Drainage capacity in the outfall systems below Ballarto Road is also affected by tidal constraints.

It follows therefore that while restrictions on development drainage should be less severe than in the KWRFPD, they should still be tighter than in areas where such downstream drainage restrictions do not apply.

For application to urban developments in Clyde Creek and Muddy Gates Creek the default criteria for automatic compliance of a temporary drainage management asset will need to ensure best practice water quality treatment outcomes and a high degree of control over peak discharge rates. The criteria are developed assuming an excavated unplanted sediment pond with average pool depth of 0.5 m is used as the management asset, and are as follows:

- 600m^3 of freeboard storage in a dam (between normal top water level and spillway level) per hectare of fully developed inlet catchment area (and including the dam area in this);

- Water surface area at NTWL to be not less than 4% of developed catchment area (excluding the dam area);

- Extended detention depth to be not less than 0.5 m;

- Outlet from the dam to be controlled to 9 1/s per hectare of catchment (including dam area) at spillway overflow level;

- No change to existing receiving drainage lines or flood levels at property boundary/ies.

Whilst the criteria above do not fully address the issue of extra volumetric runoff arising from urban development, this is offset as far as practicable by ensuring peak outlet discharges are significantly less than would occur under existing site conditions. Water is released from storage at very low rates over a much longer period of time. Computations show that the ratio of “post development” to “existing conditions” peak discharges will be as follows:

Deemed to comply standards for peak discharge from development (temporary works)	
ARI (yrs)	**Post development/Existing Conditions (%)**
1	70
10	45
100	30

9.4 Alternative Computational Requirements

Where the default "deemed to comply" solution is not favoured by the applicant the required methodology and performance standards to be applied are as follows.

Best practice water quality performance is to be demonstrated using the MUSIC model and MW's reference year of 2004 (6 minute rainfall sequence) for KooWeeRup.

For hydrologic assessments (flow and storage computations), the RORB model or equivalent is to be used.

For hydraulic modelling of one-dimensional open channel flow systems the HEC-RAS model will suffice for water level, velocity and channel shear stress computations. For more complex hydraulic situations (generally wider floodplains and/or complex backwater interactions), two-dimensional hydrodynamic models are to be used such as TuFlow or Mike 21 or their approved equivalents.

Recent research on the estimation of peak flood flows for rural catchments for Engineers Australia has been published in Australian Rainfall and Runoff (ARR) Project 5, Stage 2 Report, dated June 2012. This report recommends that ARR move to a regional regression analysis approach for calculating pre-development peak flood flows. The regional regression analysis approach is being developed by the Bureau of Meteorology, but has not yet been released for use by the industry. The report also considered the accuracy of the current ARR method (the Adams Rural Rational Method) and found that this method was appropriate, but suggested adjustment of the results for very small catchments as per the relation shown on Figure 5.3.6 of the ARR 2012 report (see below).

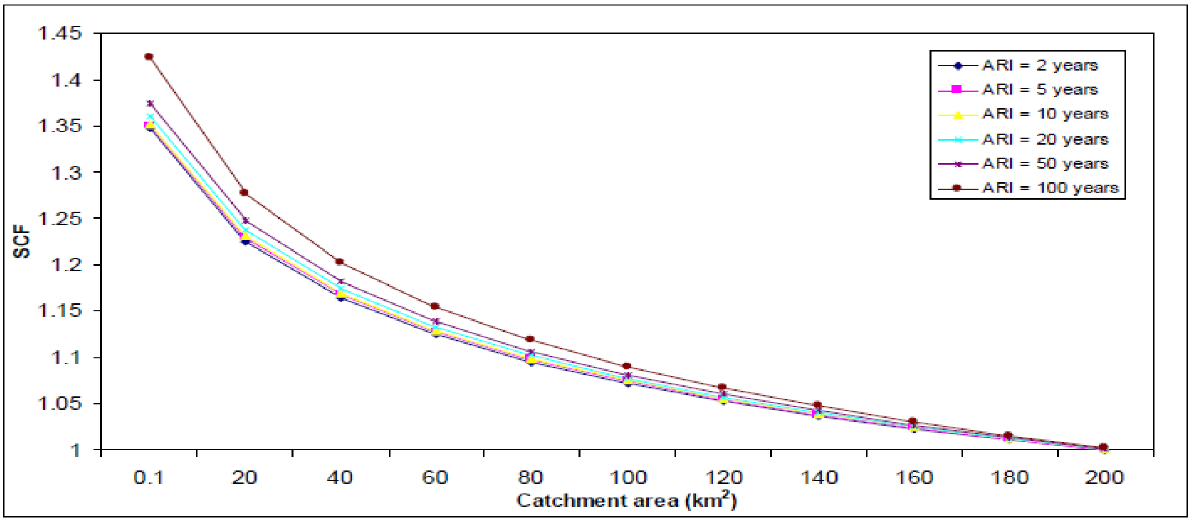


Figure 5.3.6 Relationship between scale correction factor (SCF) and catchment area

Peak flows for existing rural conditions are therefore to be derived using the current ARR Method with Adams equation for estimation of time of concentration with matched runoff coefficients, all in accord with the recommendations set out in Australian Rainfall and Runoff (ARR).

The 10 year ARI runoff coefficients provided in Volume 2 of ARR are to be used and not those listed in other references such as VicRoads Design Manuals.

The Figure 5.3.6 correction factors are then to be applied to calculated discharges.

Unless specifically directed otherwise by MW and/or Council, temporary drainage management works are to be designed to:

- ensure that discharges are less than or equal to existing conditions peak flows for all events up to and including 100 years ARI, on lands downstream of the subject property.

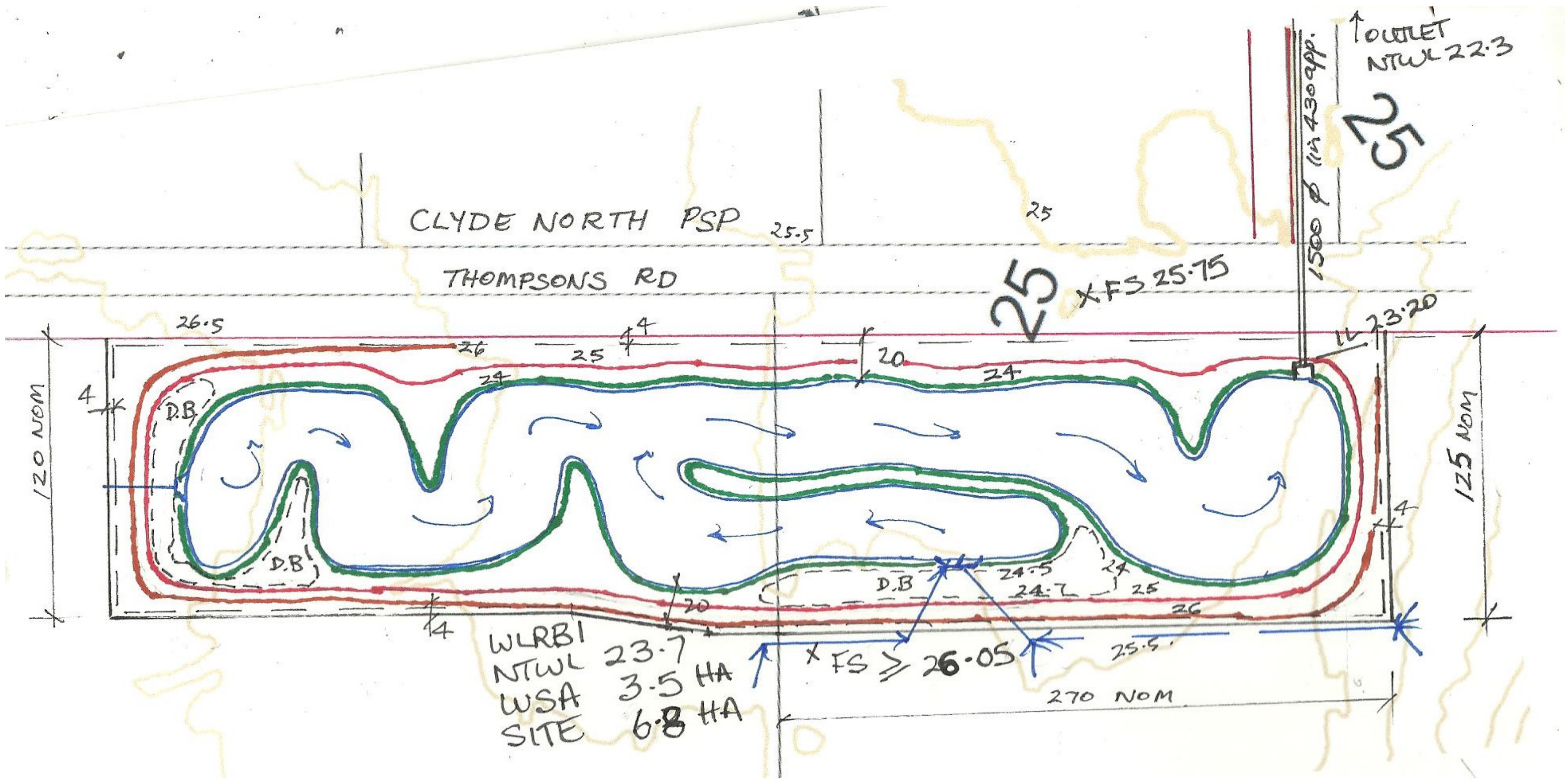
- Include measures to offset the impact of increased surface water discharge volumes from the development during the winter/spring seasons. This may include over-restriction of outlet discharge as per the default deemed to comply solution, and/or diversion of part of the flows to alternative outfalls, and/or storage reuse of water within the development.

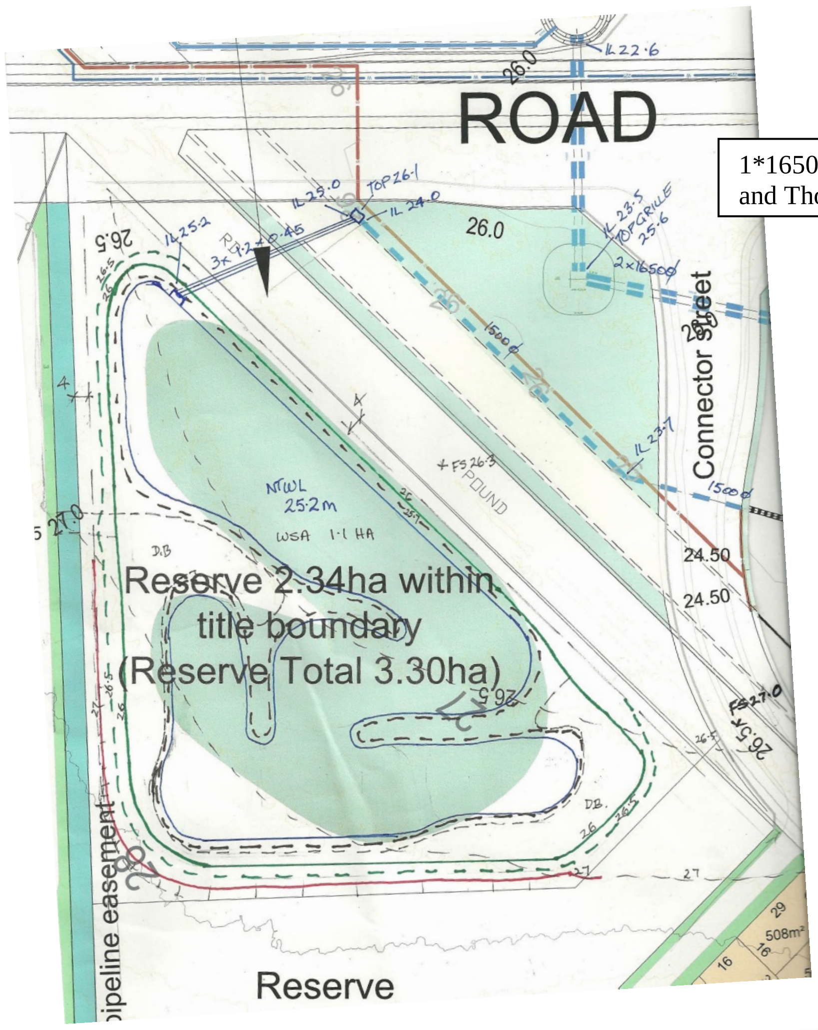
- Maintain existing conditions flood levels for all events up to and including 100 years ARI, on lands upstream and downstream of the subject property.

- Achieve best practice water quality objectives prior to water exiting from the boundaries of the relevant development. This allows for options such as overland flow dispersal across vegetated areas within a larger development to be implemented.

Bioretention or infiltration systems will <u>not be accepted</u> as temporary sediment management works for any development application.

Neil M Craigie





1*1650 Ø pipe across Connector St and Thompsons Rd

SBRB1

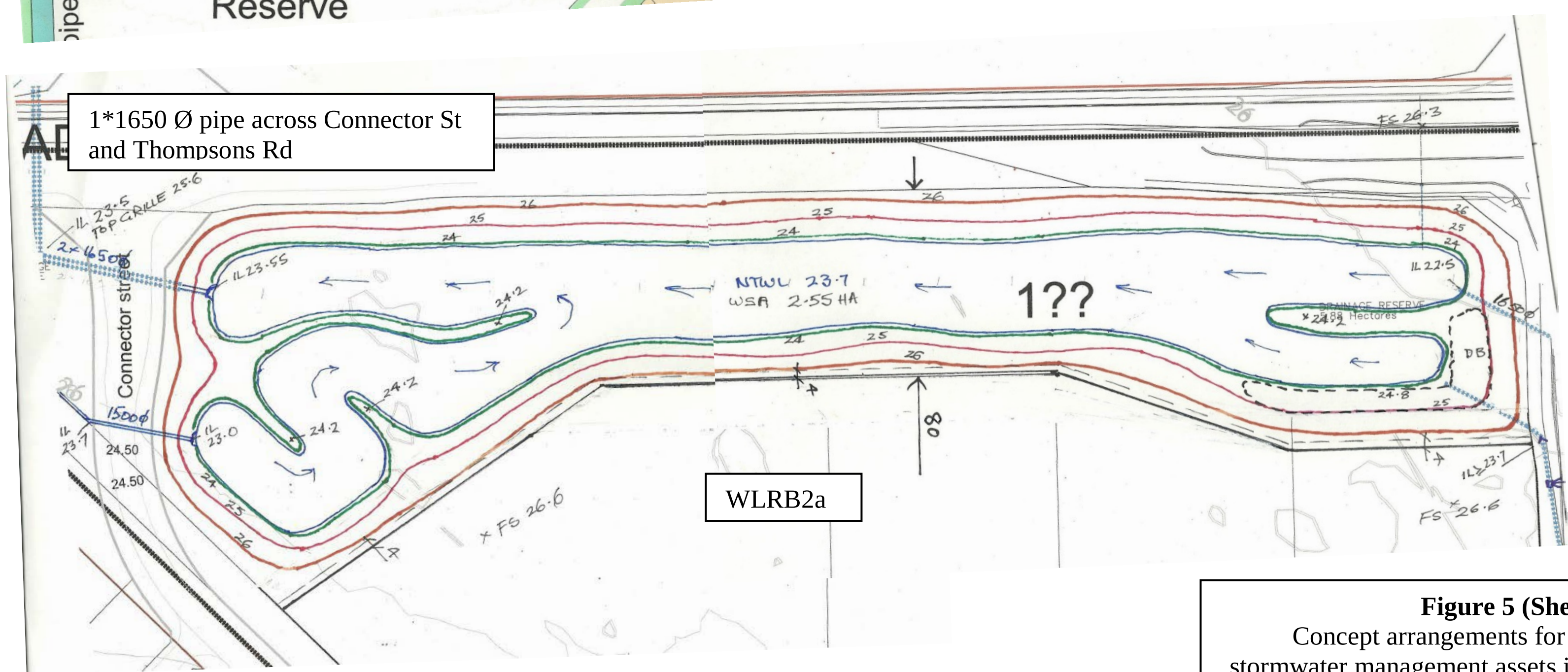
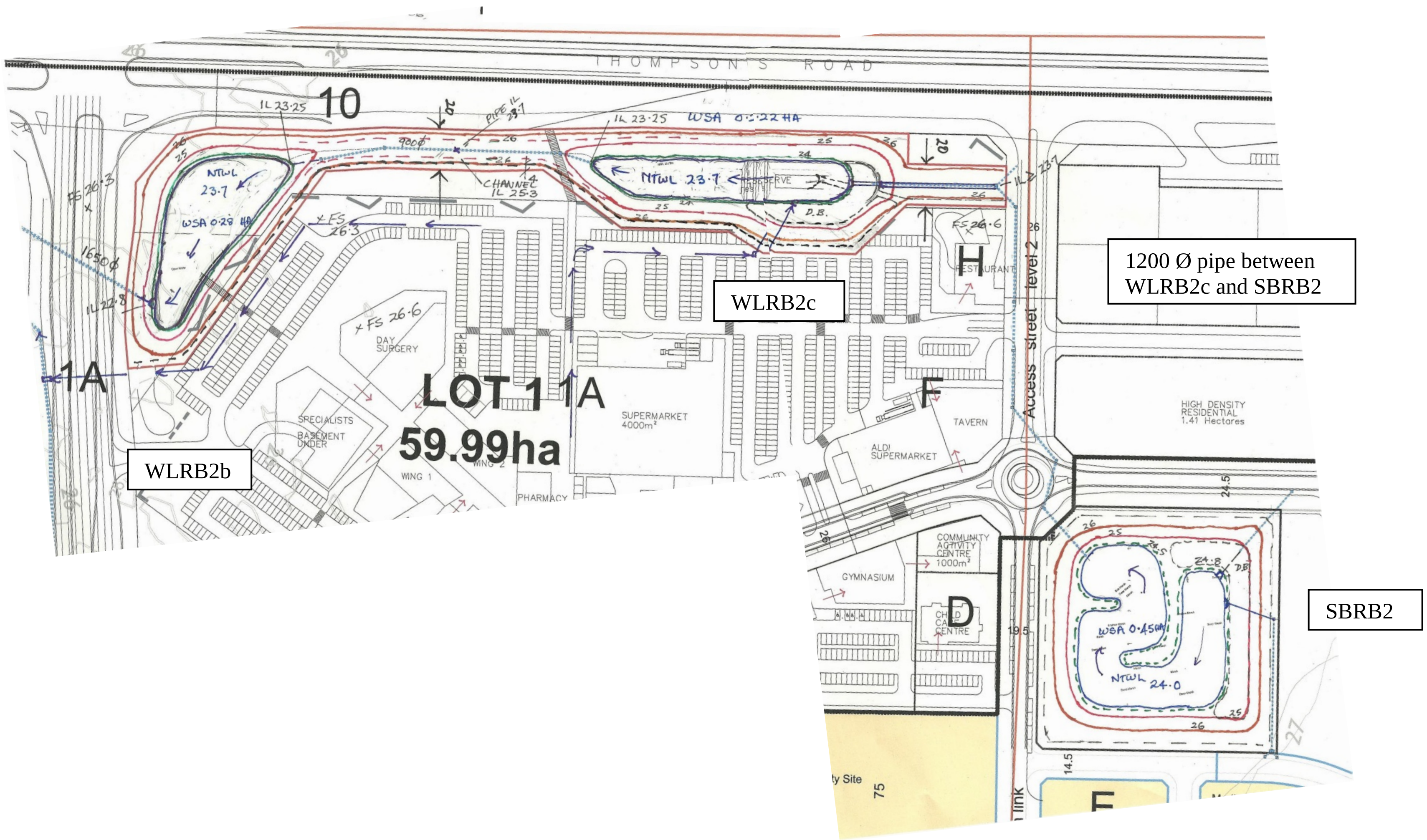


Figure 5 (Sheet 1 of 2)
Concept arrangements for proposed stormwater management assets in Ti Tree Creek and Baillieu Creek catchments (moving west-east sequentially)



--Limit of Works In Ti Tree Creek Catchment

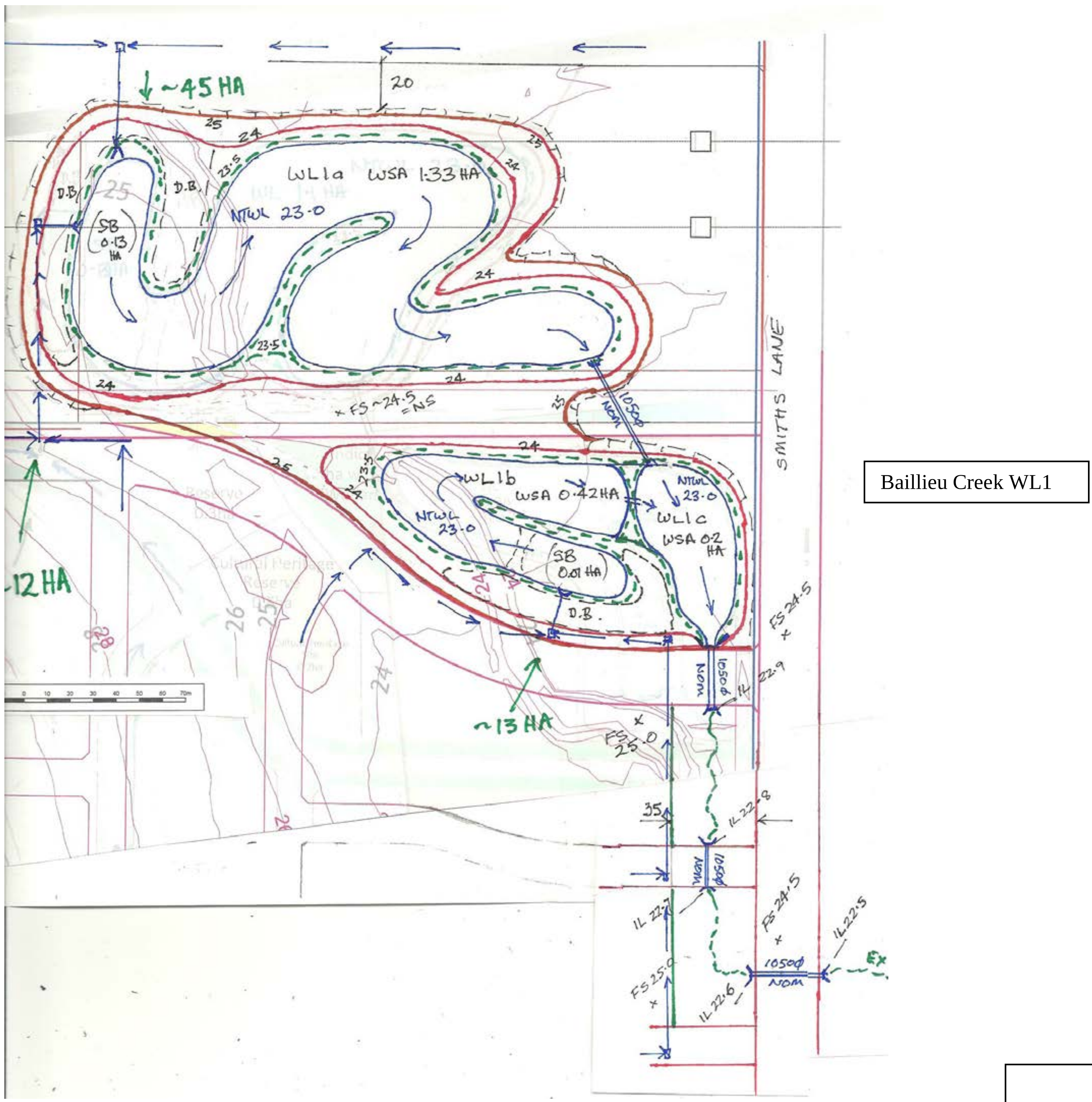
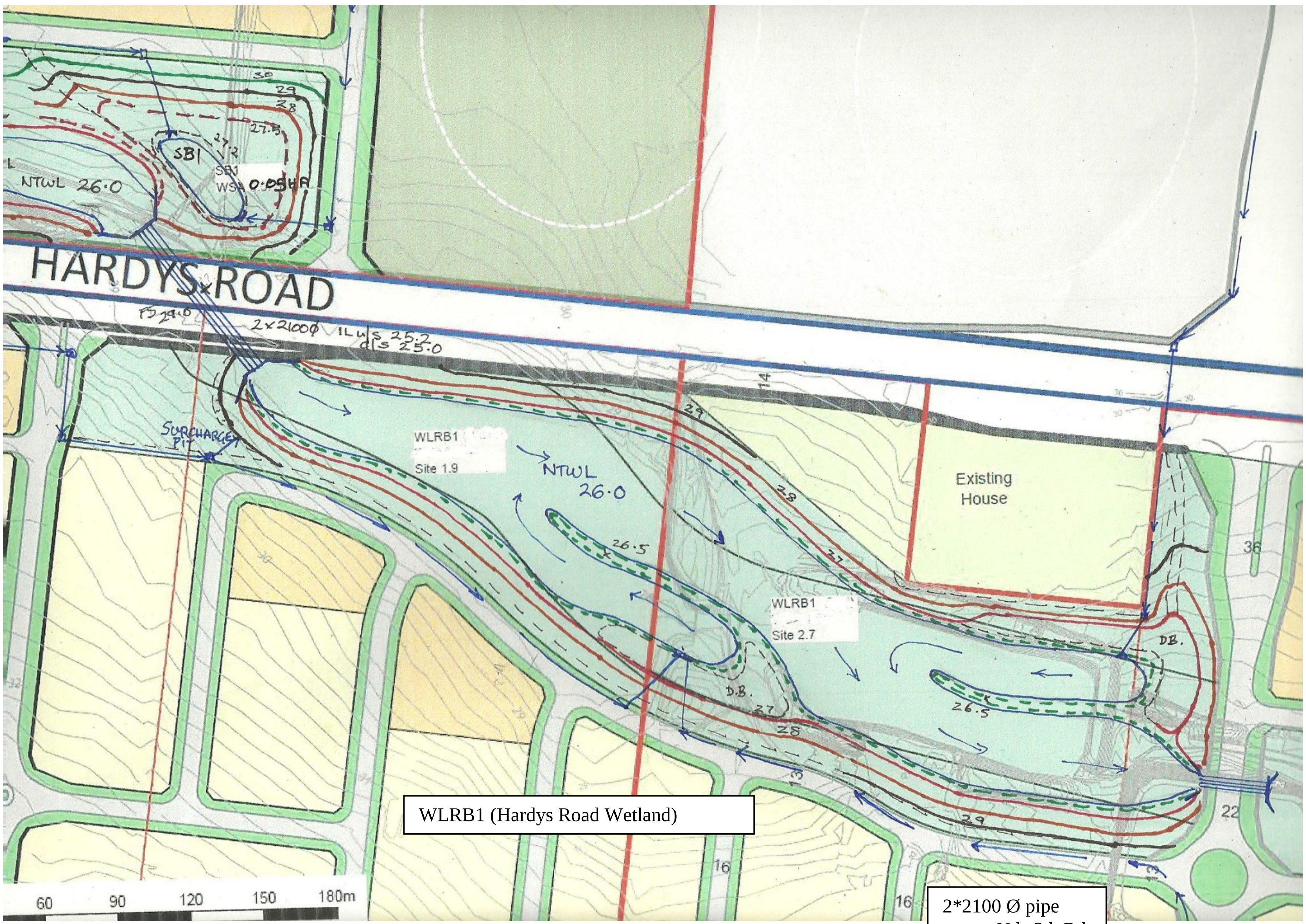
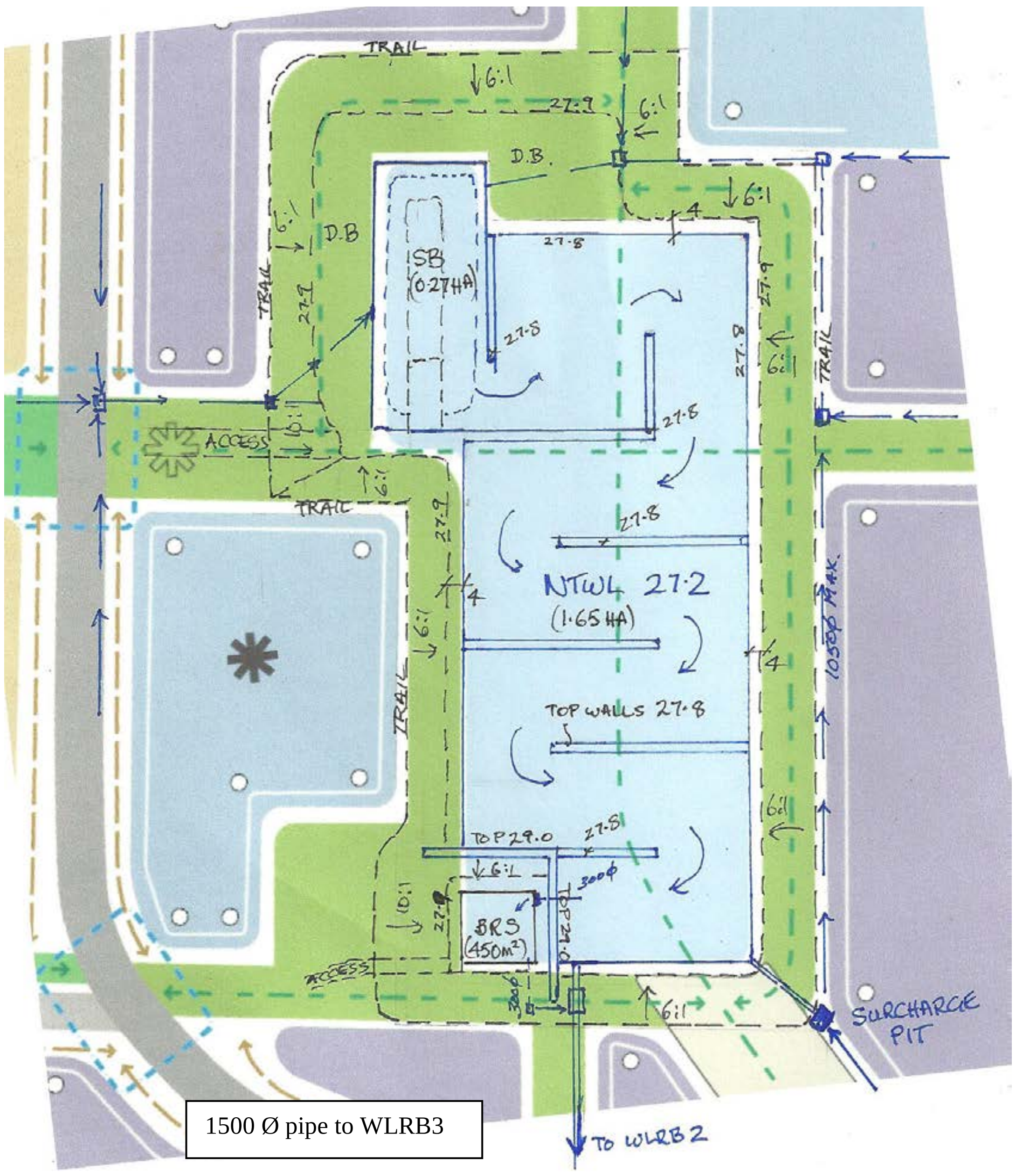


Figure 5 (Sheet 2 of 2)
Concept arrangements for proposed stormwater management assets in Ti Tree Creek and Baillieu Creek catchments (moving west-east sequentially)



WLRB1 (Hardys Road Wetland)

2*2100 Ø pipe across Nth-Sth Rd



1500 Ø pipe to WLRB3

WLRB2/BRS1 (Town Centre Urban Wetland)

Figure 6 (Sheet 1 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

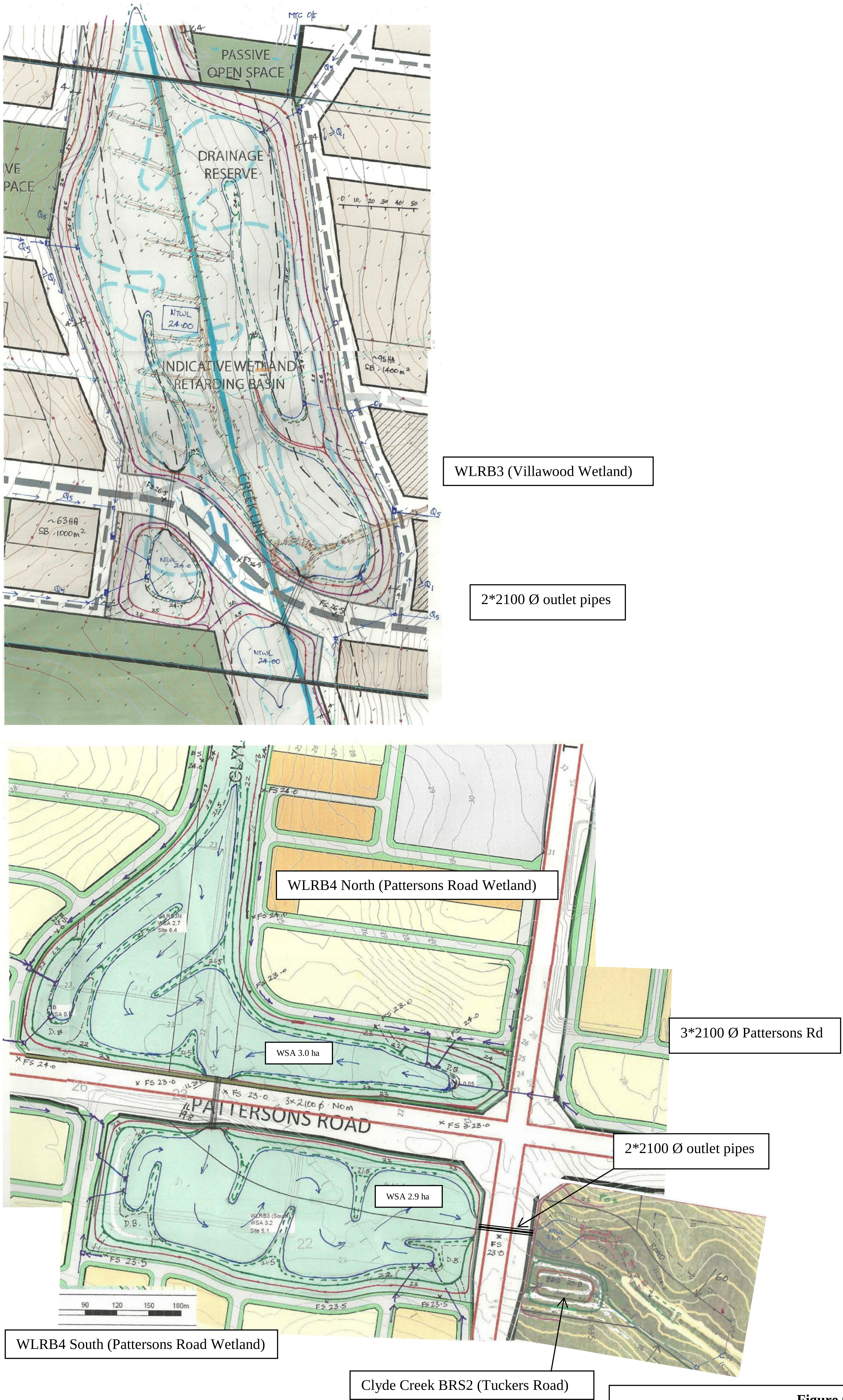


Figure 6 (Sheet 2 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

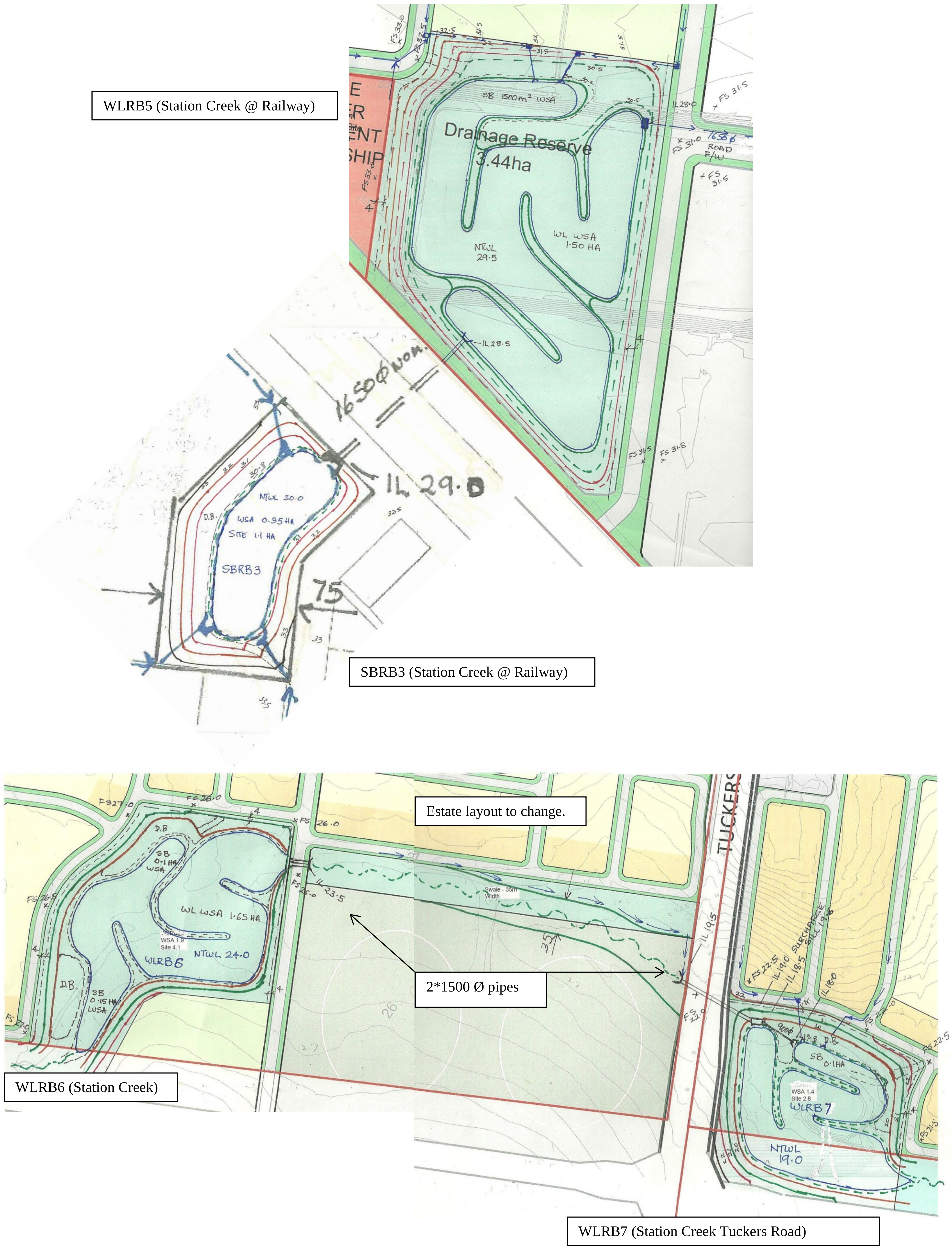


Figure 6 (Sheet 3 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

Figure 6 (Sheet 4 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

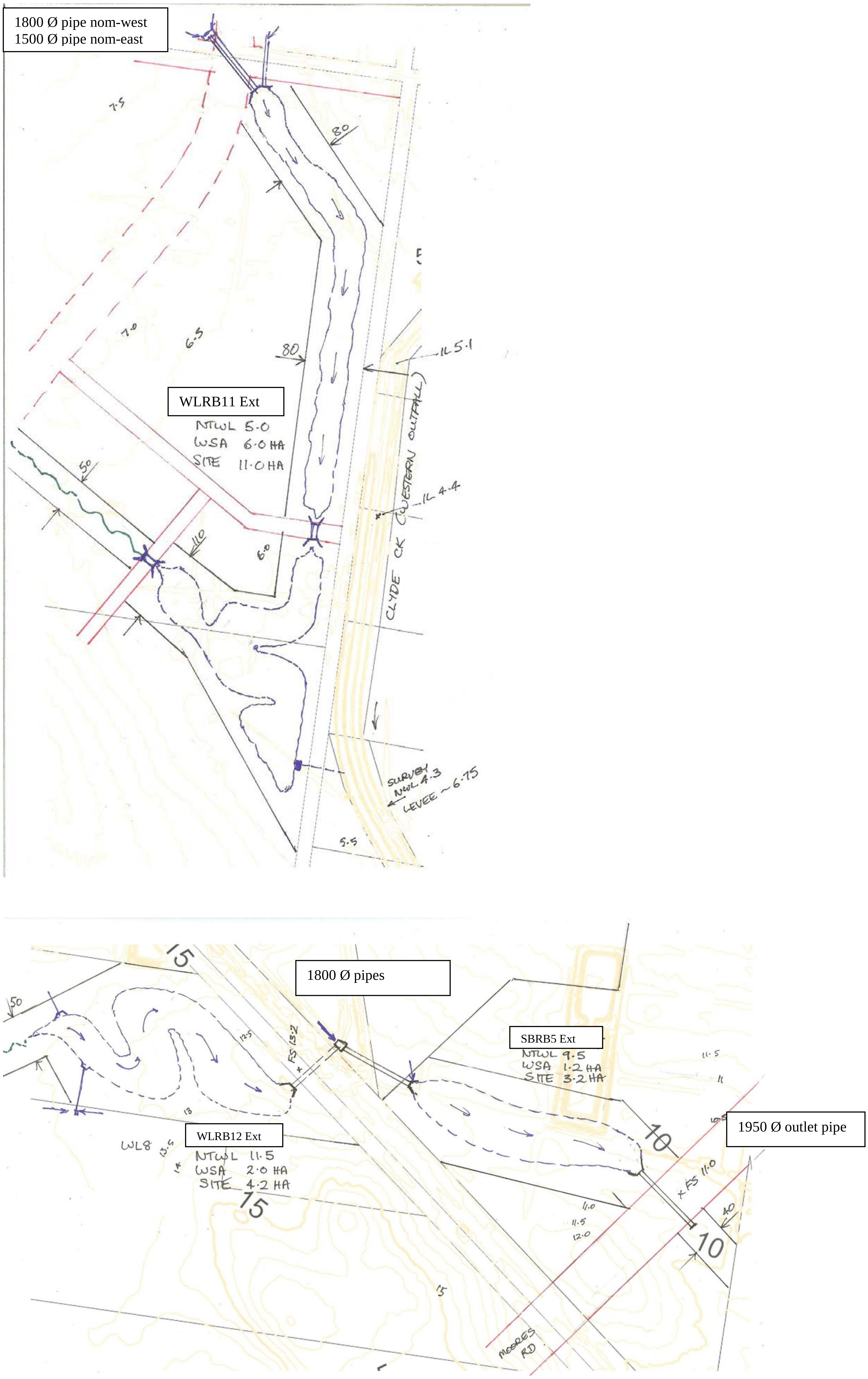


Figure 6 (Sheet 5 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

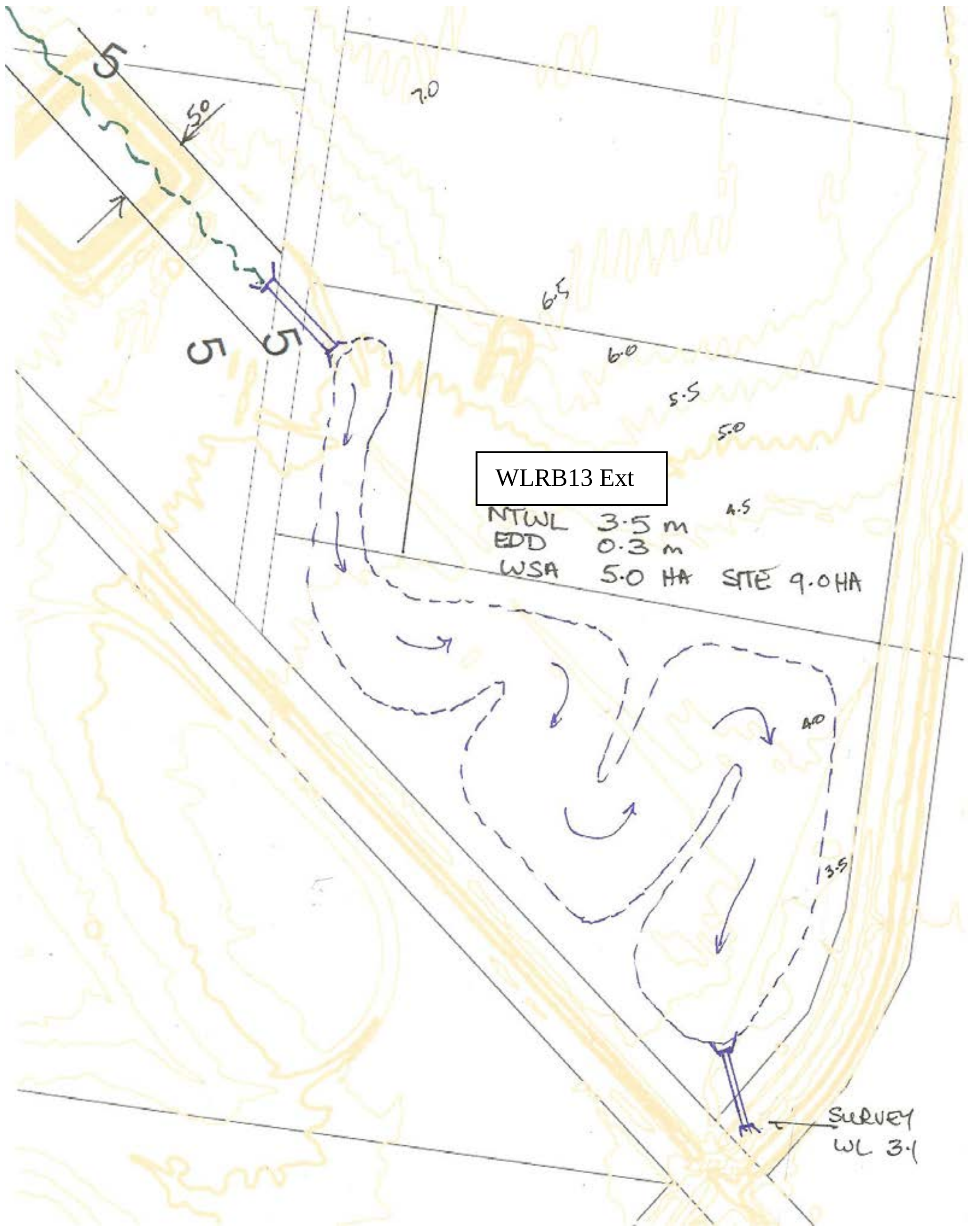


Figure 6 (Sheet 6 of 6)
Concept arrangements for proposed stormwater management assets in Clyde Creek catchment

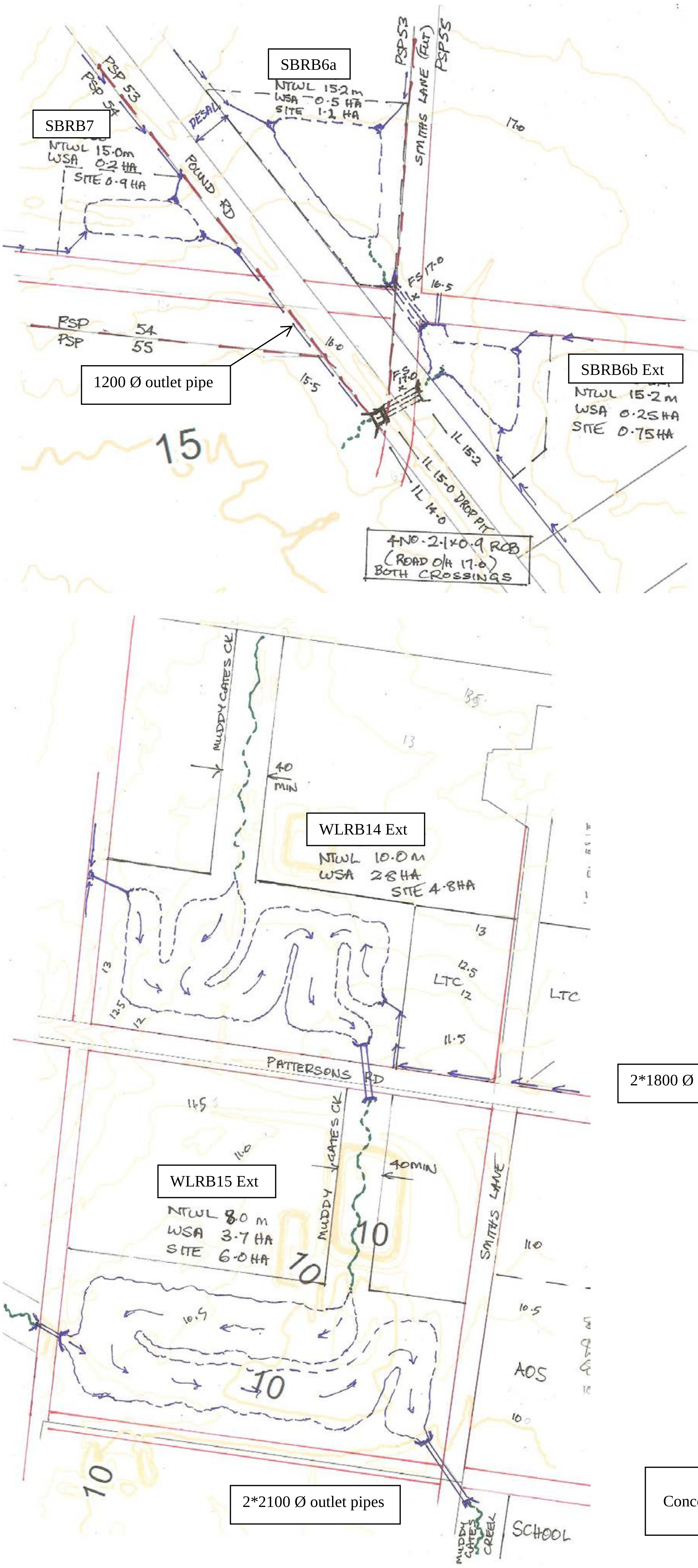
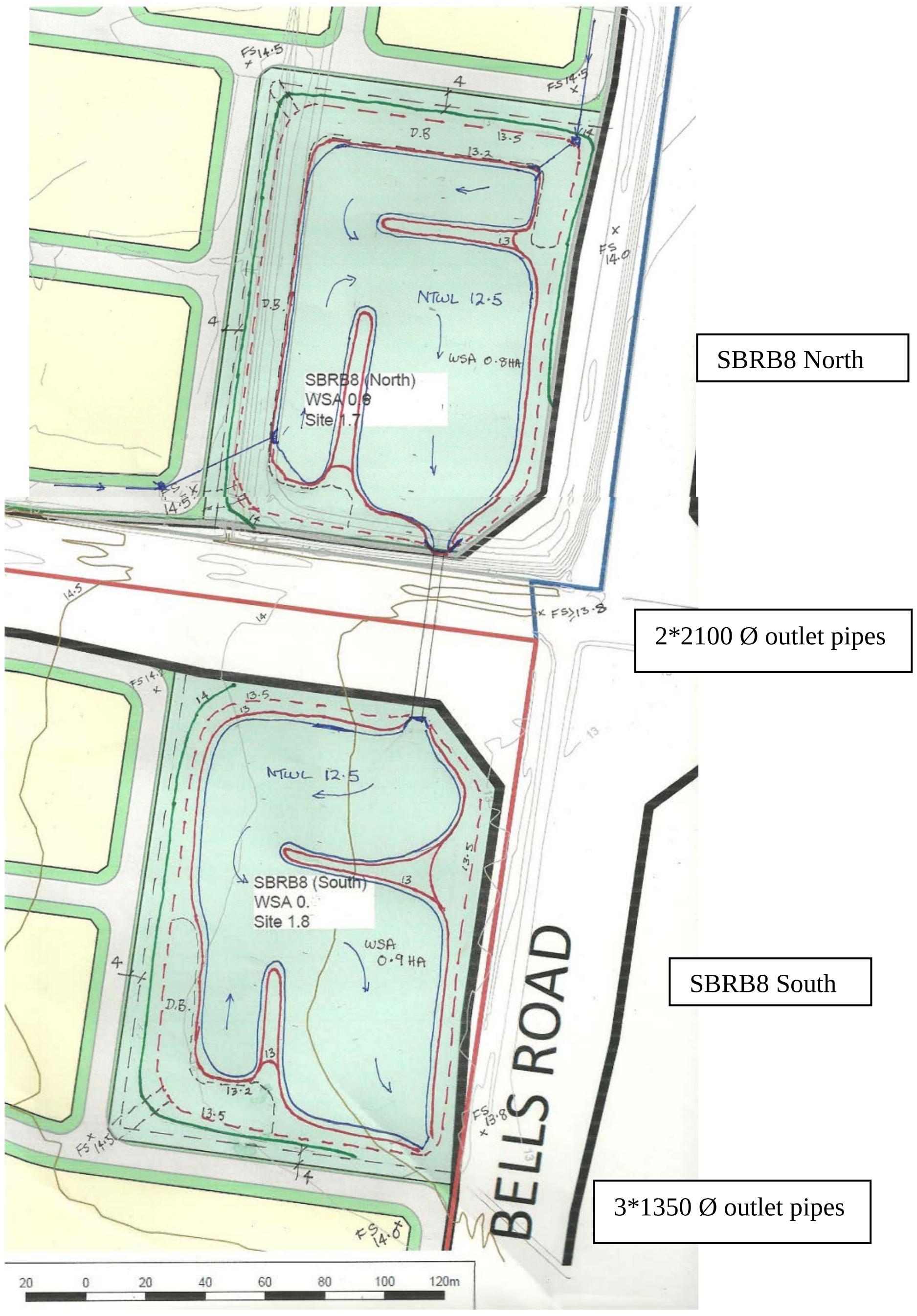


Figure 7 (Sheet 1 of 2)
Concept arrangements for proposed stormwater management assets in Muddy Gates Creek catchment



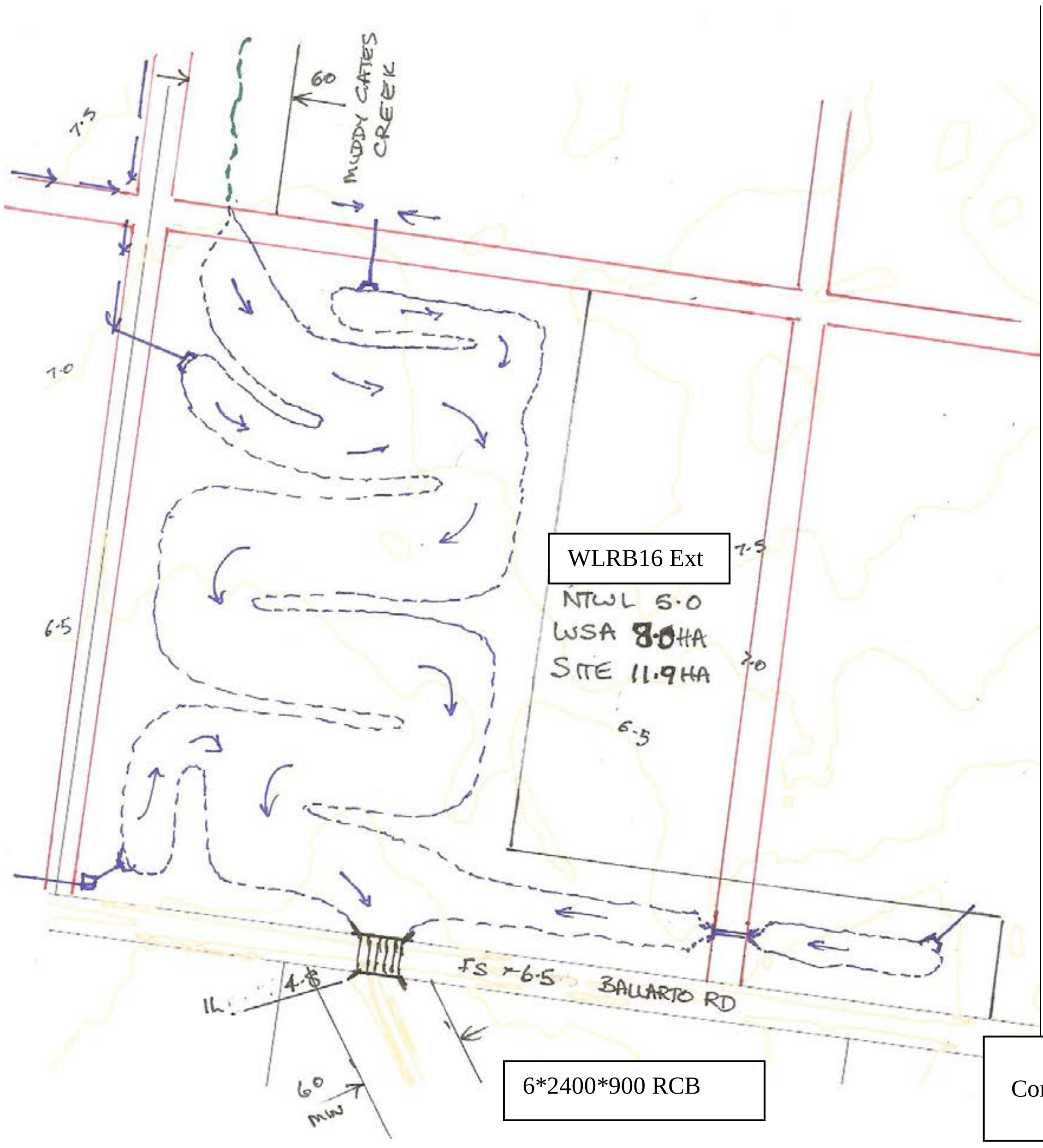


Figure 7 (Sheet 2 of 2)
Concept arrangements for proposed stormwater management assets in Muddy Gates Creek catchment

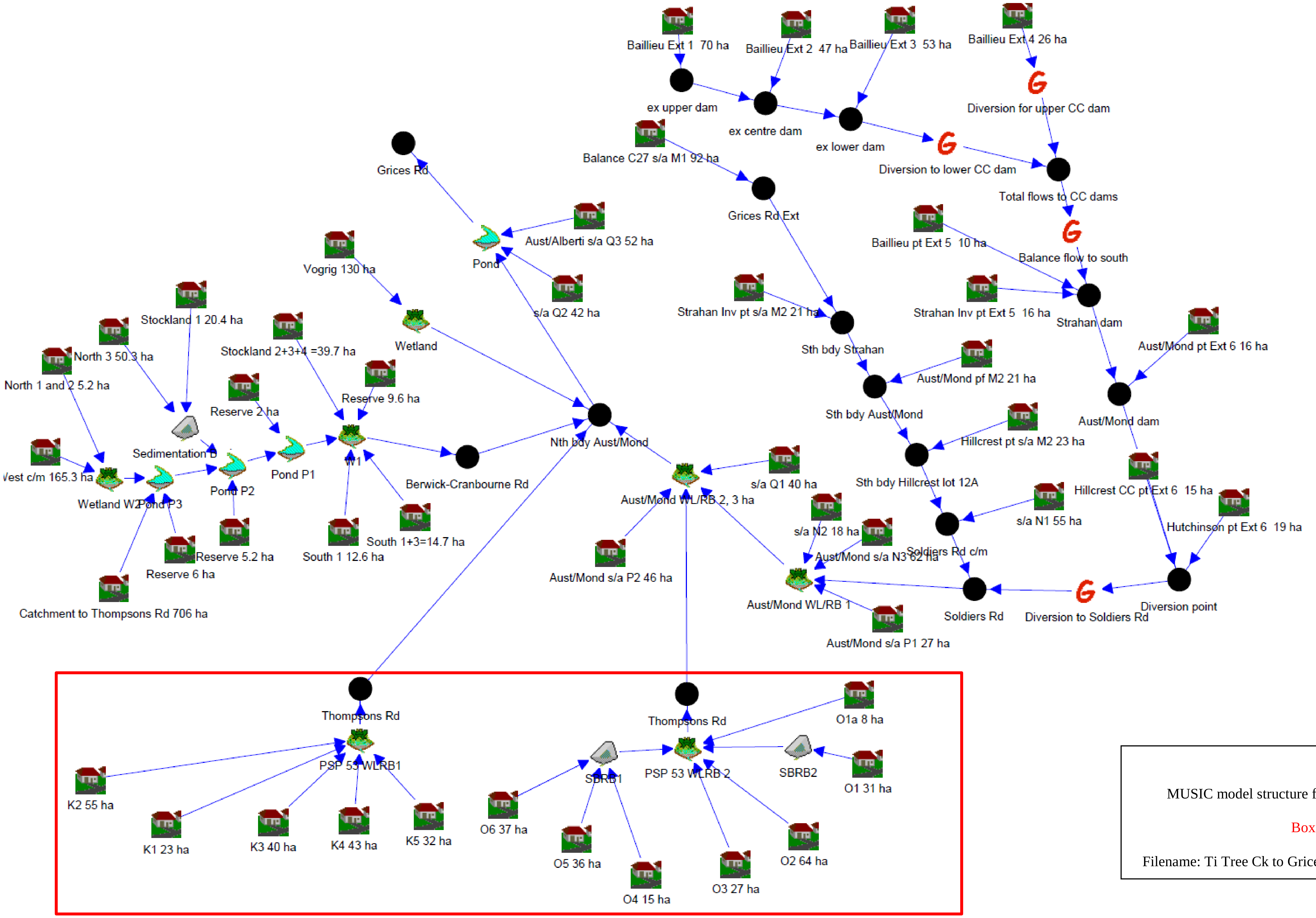


Figure 8

MUSIC model structure for Ti Tree Creek Catchment (Port Phillip Bay catchment)

Box area is the PSP 53 subcatchments

Filename: Ti Tree Ck to Grices Rd Dec 2013 KWR 2004 6 min

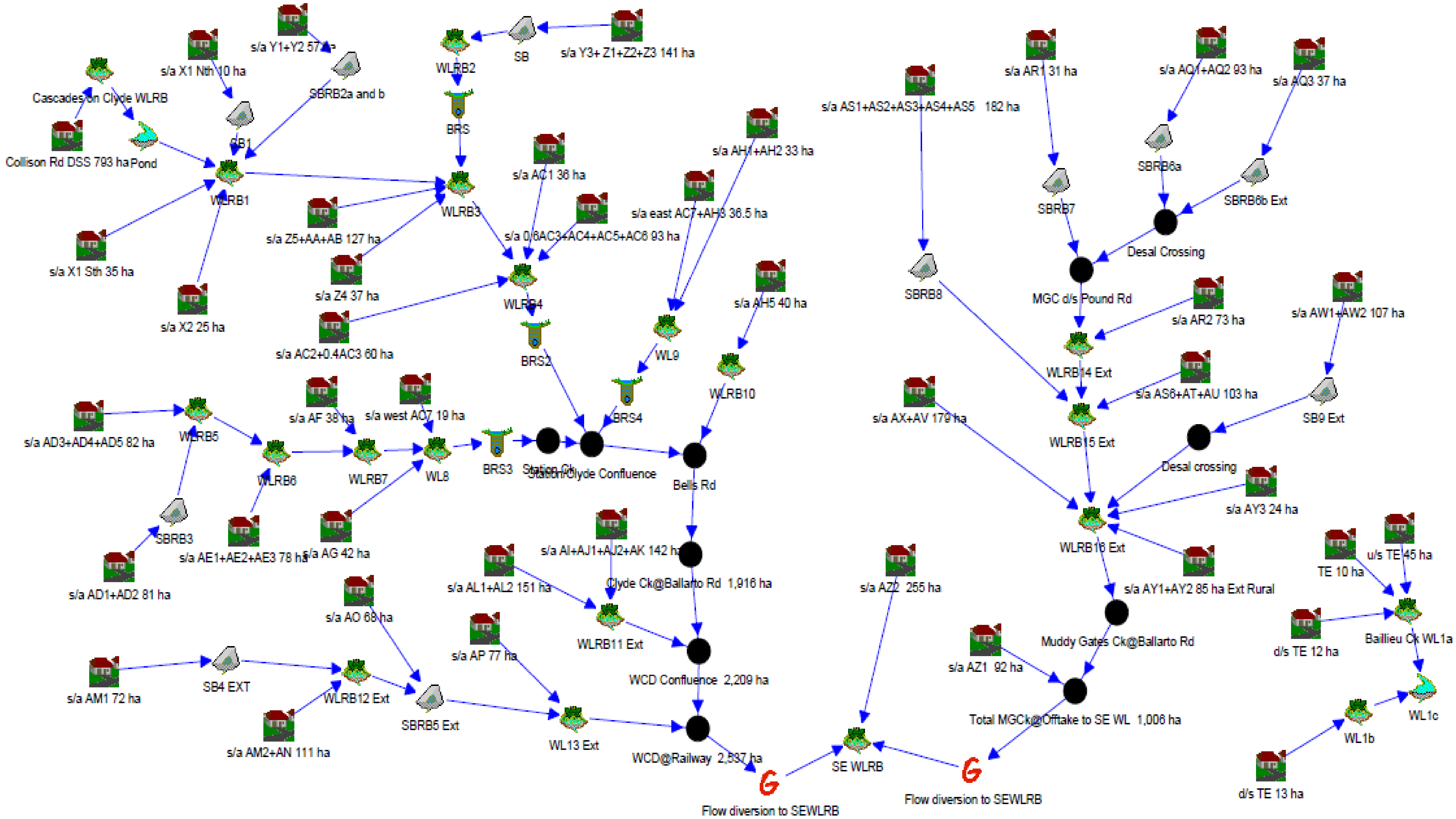


Figure 9

MUSIC model structure for Clyde Creek/Muddy Gates Creek/Cardinia Creek Catchments (Western Port catchment)

Filename: PSP 53 and 54 V2 3 Dec 13 KWR 2004 6 min

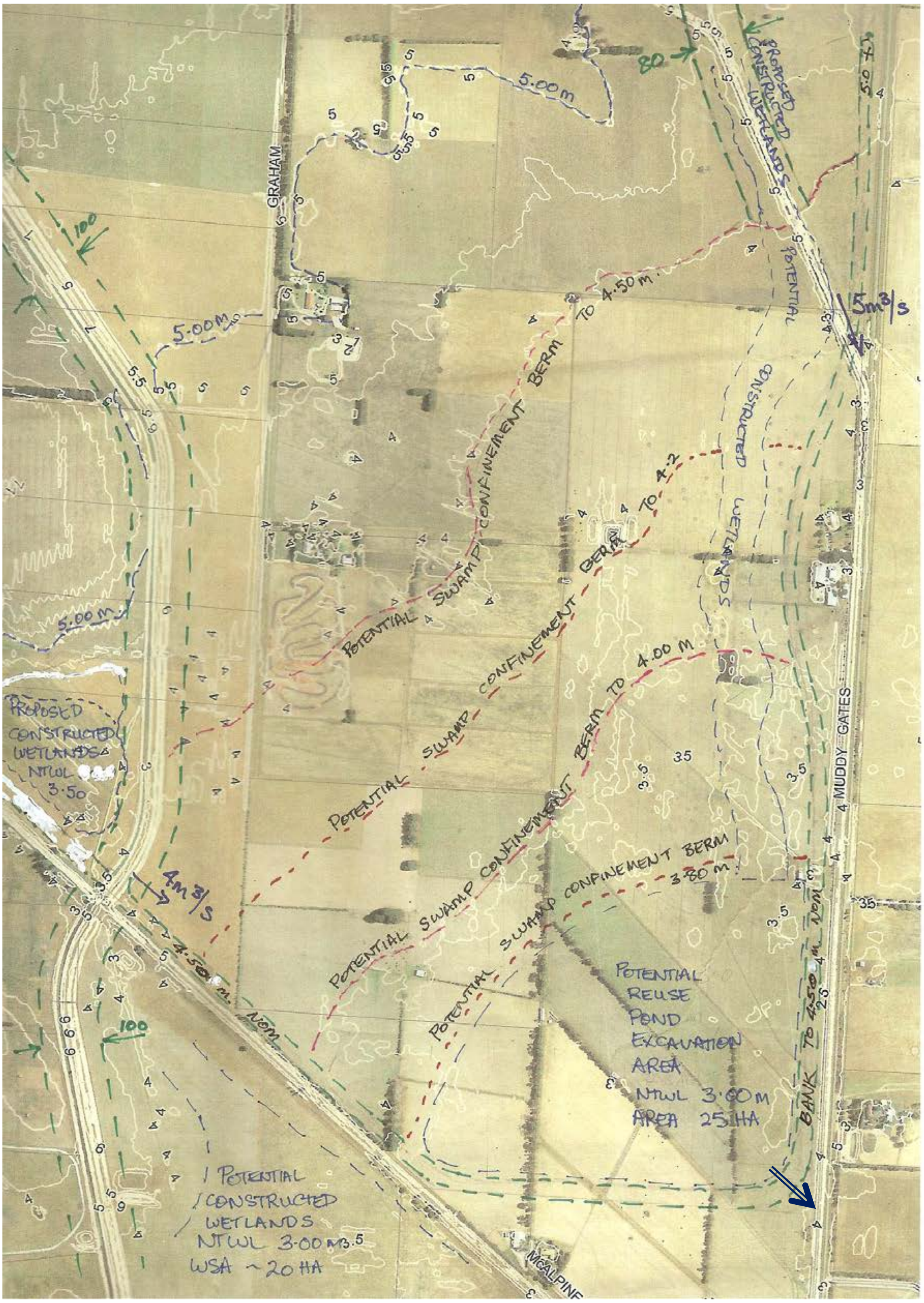


Figure 10 Revised Concept for proposed SE WLRB (North Segment)

Embankment crest level <=4.50 m

100 year ARI flood level 4.20 m-bank terminates at this surface level at northern end.

APPENDIX A

HEC-RAS ASSESSMENTS FOR CLYDE CREEK AND MUDDY GATES CREEK OUTFALLS DOWNSTREAM OF BALLARTO ROAD

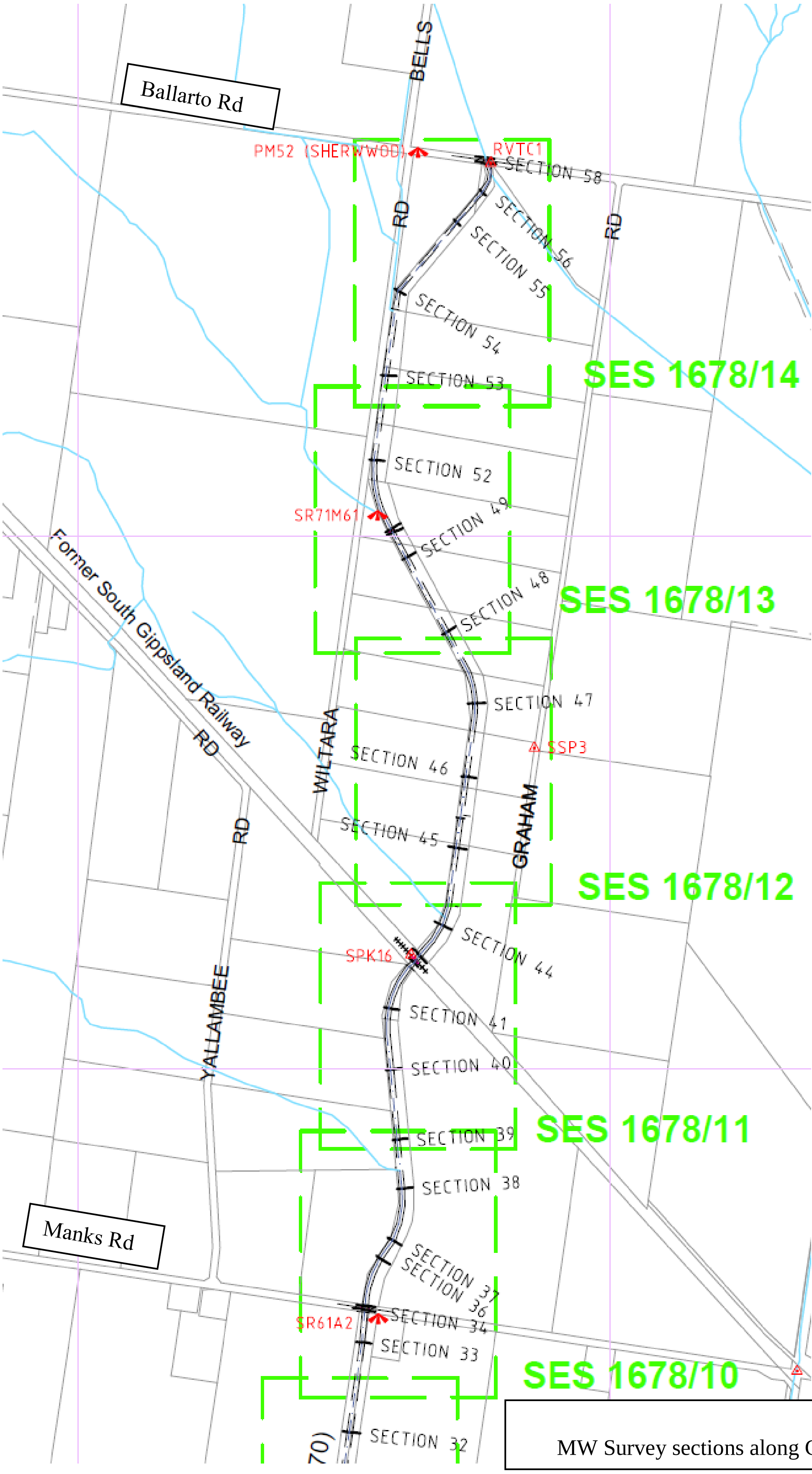


Figure A.1
MW Survey sections along Clyde Creek

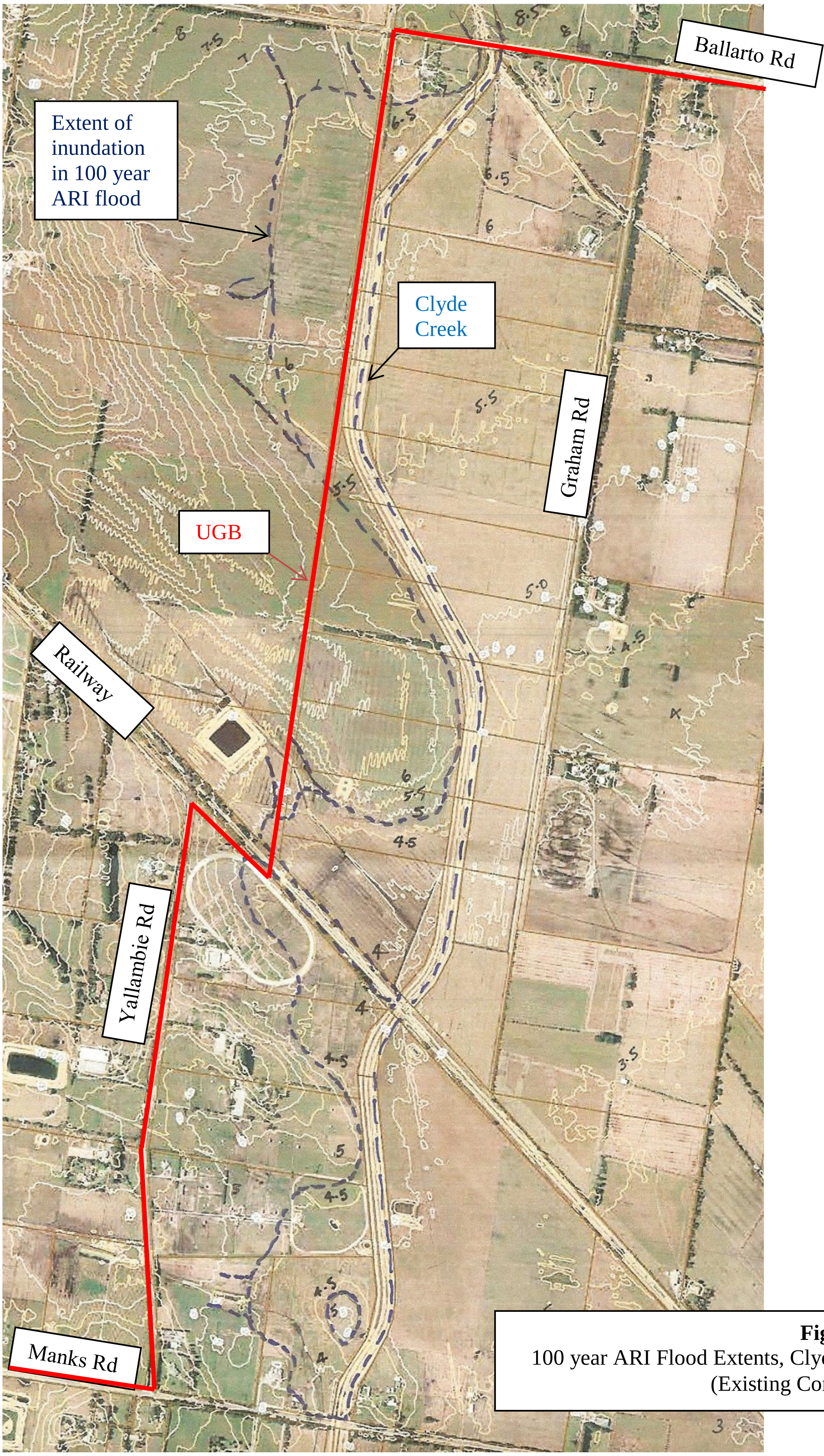
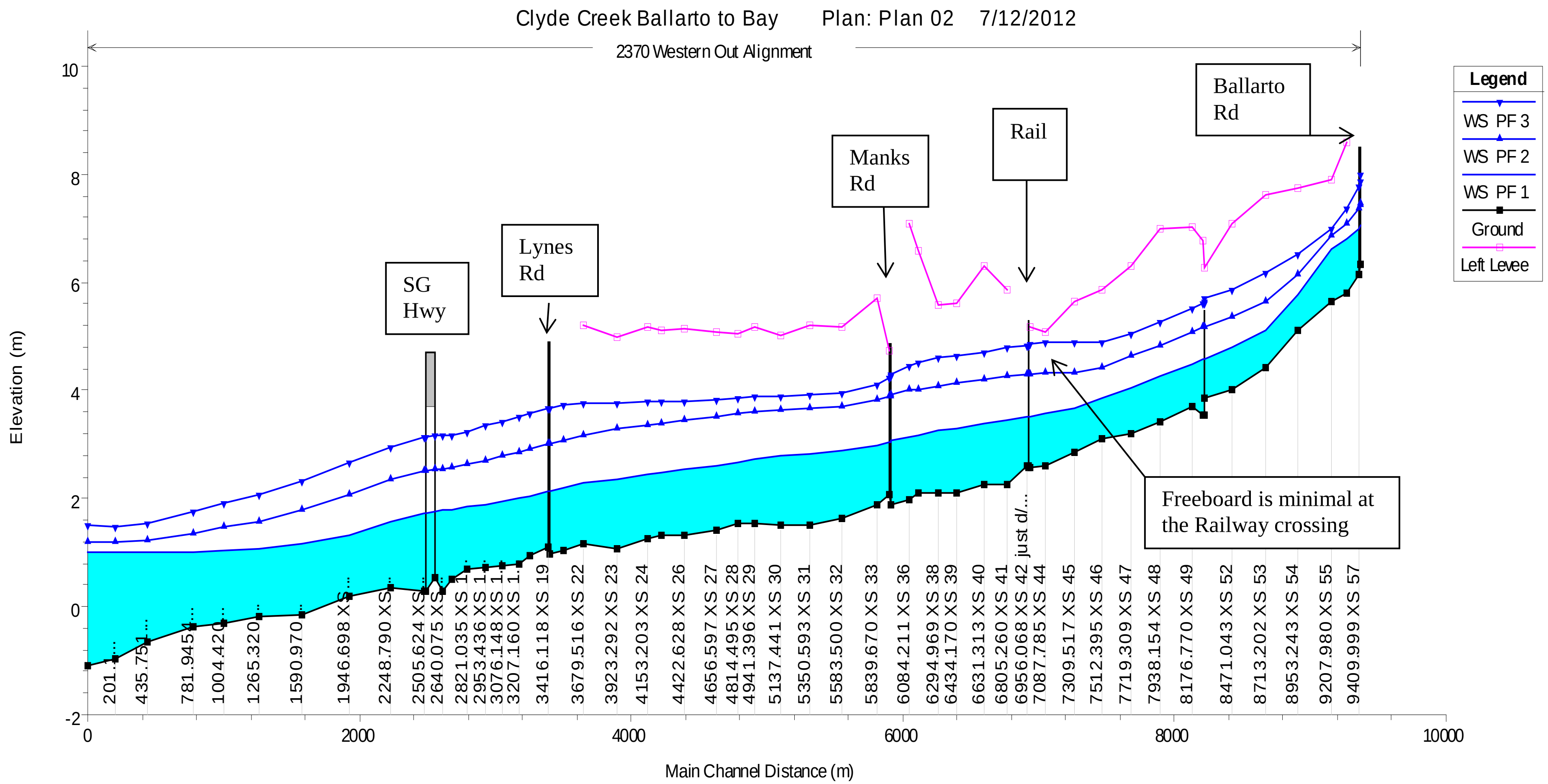
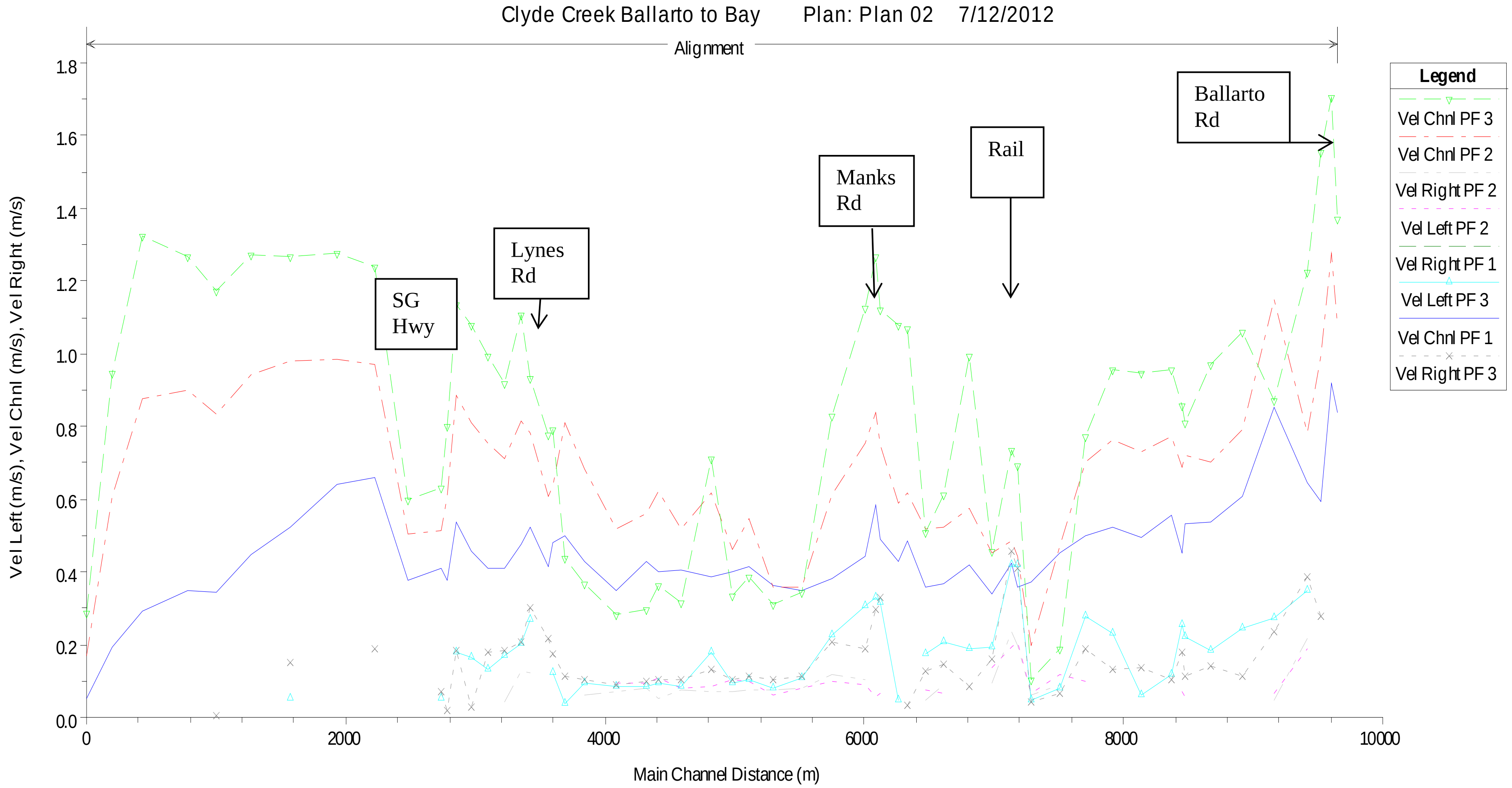


Figure A.2
100 year ARI Flood Extents, Clyde Creek
(Existing Conditions)



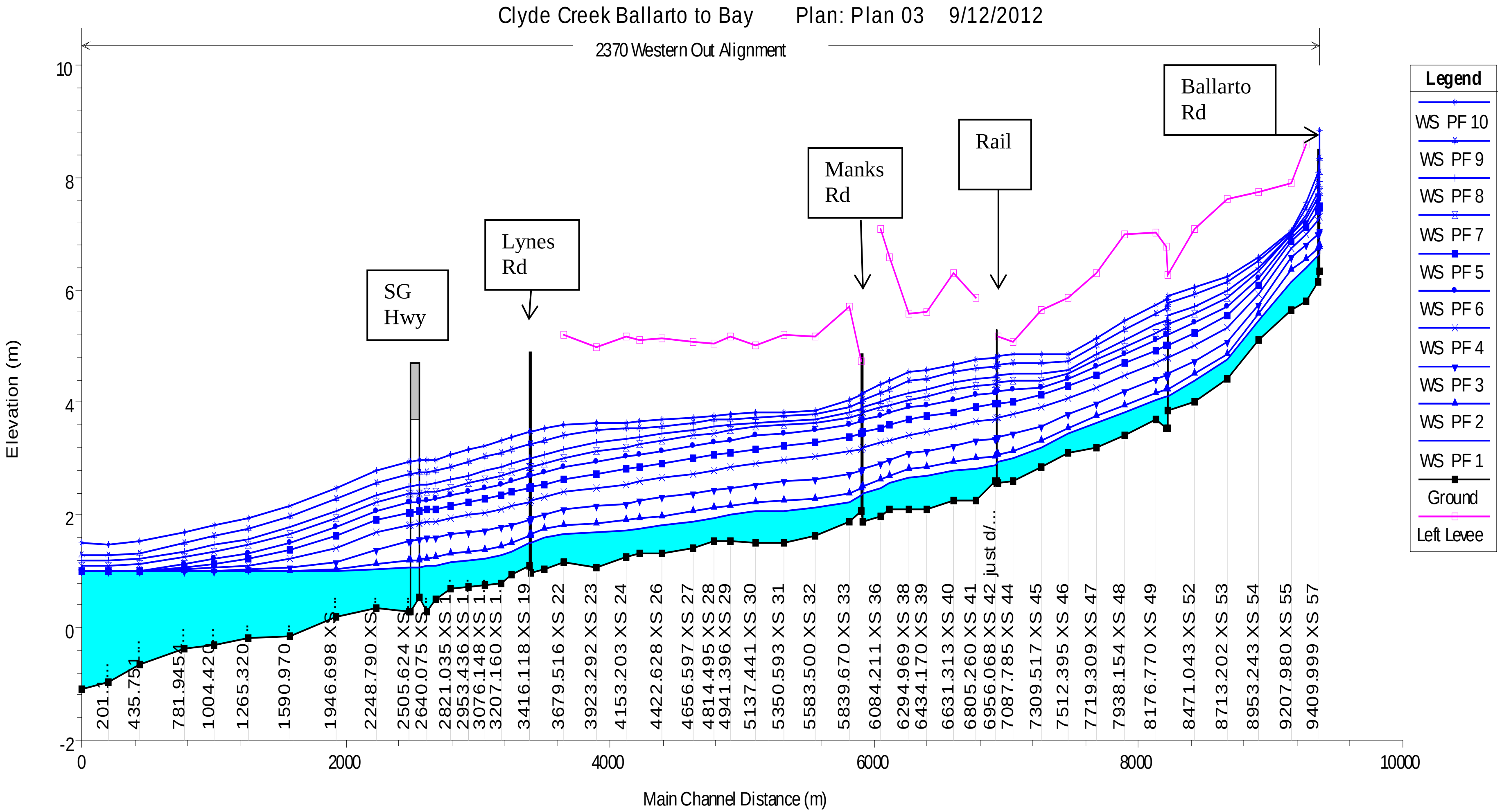
Notes: PF1=1 year ARI, PF2=10 yr ARI, PF3=100 yr ARI under existing conditions. Refer to Table A.1 for results at each Section (XS).

Figure A.3
1, 10, 100 year ARI Flood profiles, Clyde Creek



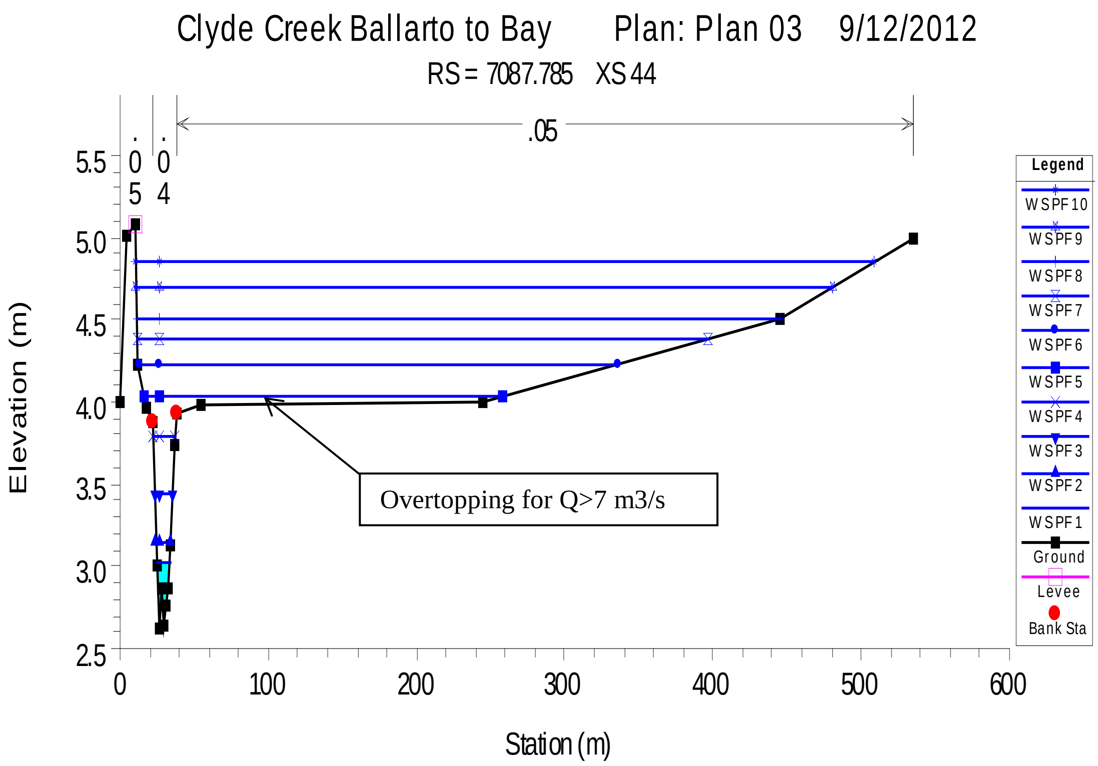
Notes: PF1=1 year ARI, PF2=10 yr ARI, PF3=100 yr ARI. Refer to Table A.1 for results at each Section (XS).

Figure A.4
1, 10, 100 year ARI Flood velocities, Clyde Creek



Profiles for 25, 20, 15, 12.5, 10, 7.5, 5, 2.5, 1, and 0.5 m3/s respectively, for threshold capacity checks.

Figure A.5
Trial flow profiles, Clyde Creek



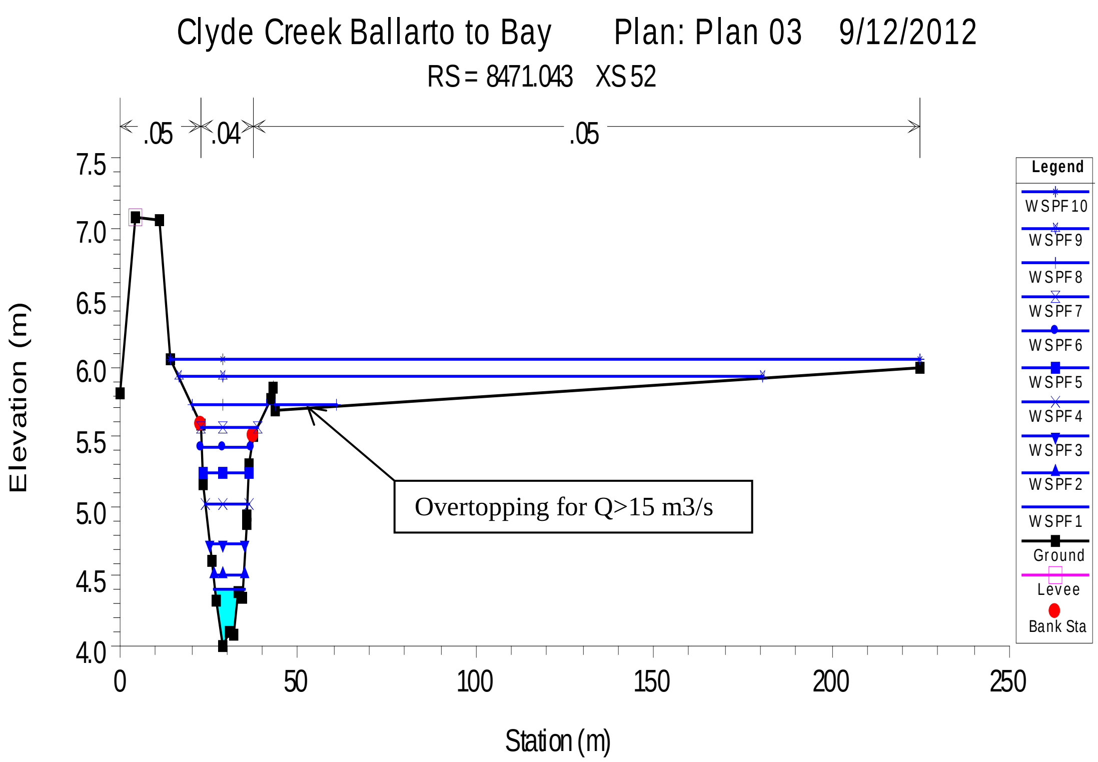


Figure A.6
Water levels at sites for WLRB7 Ext (above) and WLRB8b Ext. Clyde Creek (Existing Conditions)

TABLE A.1 HEC-RAS Results for Existing Conditions, Clyde Creek
(Results downstream of XS 30 are preliminary only, used to assess control levels at Manks Rd, and are subject to revision.)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
9424.875	58	1	2.60	6.32	7.06	7.10	0.003560	0.84
9424.875		10	7.10	6.32	7.46	7.52	0.003382	1.08
9424.875		100	16.20	6.32	7.99	8.08	0.002485	1.37
9423	Ballarto Road		Bridge					
9409.999	57	1	2.60	6.16	7.00	7.04	0.003974	0.92
9409.999		10	7.10	6.16	7.37	7.46	0.004818	1.28
9409.999		100	16.20	6.16	7.79	7.94	0.005287	1.70
9319.115	56	1	2.60	5.80	6.81	6.83	0.001576	0.59
9319.115		10	7.10	5.80	7.09	7.14	0.002778	1.00
9319.115		100	16.20	5.80	7.38	7.50	0.004852	1.55
9207.980	55	1	2.60	5.66	6.60	6.62	0.002151	0.65
9207.980		10	7.10	5.66	6.87	6.89	0.001681	0.78
9207.980		100	16.20	5.66	6.98	7.03	0.003399	1.23
8953.243	54	1	2.90	5.10	5.77	5.81	0.004975	0.85
8953.243		10	8.80	5.10	6.15	6.22	0.004170	1.15
8953.243		100	21.00	5.10	6.53	6.55	0.001270	0.87
8713.202	53	1	2.90	4.43	5.13	5.15	0.001751	0.61
8713.202		10	8.80	4.43	5.65	5.68	0.001379	0.79
8713.202		100	21.00	4.43	6.17	6.22	0.001443	1.06
8471.043	52	1	2.90	4.01	4.79	4.81	0.001128	0.54
8471.043		10	8.80	4.01	5.38	5.40	0.000934	0.70
8471.043		100	21.00	4.01	5.88	5.92	0.001063	0.97
8267.902	51	1	3.00	3.85	4.58	4.59	0.001031	0.53
8267.902		10	9.50	3.85	5.19	5.21	0.000959	0.72
8267.902		100	18.00	3.85	5.71	5.75	0.000695	0.81
8264.7	Farm Crossing		Bridge					
8257.853	50	1	3.00	3.56	4.57	4.58	0.000604	0.45
8257.853		10	9.50	3.56	5.16	5.19	0.000801	0.69
8257.853		100	18.00	3.56	5.62	5.65	0.000779	0.86
8176.770	49	1	3.00	3.69	4.50	4.51	0.001155	0.56
8176.770		10	9.50	3.69	5.08	5.11	0.001148	0.77
8176.770		100	18.00	3.69	5.53	5.58	0.001098	0.95
7938.154	48	1	3.00	3.42	4.26	4.28	0.000847	0.49
7938.154		10	9.50	3.42	4.84	4.86	0.000903	0.73
7938.154		100	18.00	3.42	5.28	5.33	0.001010	0.95
7719.309	47	1	3.00	3.20	4.06	4.07	0.001027	0.52
7719.309		10	9.50	3.20	4.63	4.66	0.001030	0.76

TABLE A.1 HEC-RAS Results for Existing Conditions, Clyde Creek
(Results downstream of XS 30 are preliminary only, used to assess control levels at Manks Rd, and are subject to revision.)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
7719.309		100	18.00	3.20	5.05	5.10	0.001086	0.96
7512.395	46	1	3.00	3.10	3.85	3.86	0.001003	0.50
7512.395		10	9.50	3.10	4.43	4.46	0.000873	0.70
7512.395		100	18.00	3.10	4.90	4.93	0.000629	0.77
7309.517	45	1	3.00	2.86	3.68	3.69	0.000749	0.45
7309.517		10	9.50	2.86	4.34	4.35	0.000328	0.47
7309.517		100	18.00	2.86	4.90	4.90	0.000031	0.19
7087.785	44	1	3.00	2.62	3.56	3.57	0.000407	0.37
7087.785		10	9.50	2.62	4.33	4.33	0.000050	0.20
7087.785		100	18.00	2.62	4.90	4.90	0.000008	0.10
6979.721	43	1	3.20	2.59	3.52	3.53	0.000394	0.36
6979.721		10	10.50	2.59	4.31	4.32	0.000217	0.44
6979.721		100	25.70	2.59	4.87	4.89	0.000329	0.69
6965	Rail		Bridge					
6956.068	42	1	3.20	2.60	3.50	3.51	0.000567	0.42
6956.068		10	10.50	2.60	4.29	4.31	0.000278	0.48
6956.068		100	25.70	2.60	4.83	4.86	0.000402	0.74
6805.260	41	1	3.20	2.27	3.44	3.45	0.000279	0.34
6805.260		10	10.50	2.27	4.26	4.27	0.000211	0.45
6805.260		100	25.70	2.27	4.81	4.82	0.000140	0.46
6631.313	40	1	3.20	2.25	3.38	3.39	0.000482	0.42
6631.313		10	10.50	2.25	4.20	4.22	0.000411	0.58
6631.313		100	25.70	2.25	4.71	4.76	0.000842	0.99
6434.170	39	1	3.20	2.09	3.30	3.31	0.000347	0.37
6434.170		10	10.50	2.09	4.13	4.15	0.000307	0.52
6434.170		100	25.70	2.09	4.65	4.66	0.000278	0.61
6294.969	38	1	3.20	2.09	3.25	3.26	0.000329	0.36
6294.969		10	10.50	2.09	4.09	4.11	0.000300	0.52
6294.969		100	25.70	2.09	4.62	4.63	0.000189	0.51
6146.055	37	1	3.20	2.10	3.18	3.19	0.000710	0.48
6146.055		10	10.50	2.10	4.03	4.05	0.000503	0.62
6146.055		100	25.70	2.10	4.51	4.57	0.001154	1.07
6084.211	36	1	3.20	1.98	3.14	3.15	0.000502	0.43
6084.211		10	10.50	1.98	4.00	4.02	0.000410	0.59
6084.211		100	25.70	1.98	4.44	4.50	0.001066	1.08
5942.075	35	1	4.00	1.88	3.06	3.07	0.000602	0.49
5942.075		10	15.00	1.88	3.91	3.94	0.000714	0.75
5942.075		100	30.00	1.88	4.28	4.35	0.001124	1.12

TABLE A.1 HEC-RAS Results for Existing Conditions, Clyde Creek
(Results downstream of XS 30 are preliminary only, used to assess control levels at Manks Rd, and are subject to revision.)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
5940	Manks Road		Bridge					
5930.757	34	1	4.00	2.07	3.04	3.06	0.000966	0.58
5930.757		10	15.00	2.07	3.88	3.92	0.001002	0.84
5930.757		100	30.00	2.07	4.23	4.31	0.001609	1.27
5839.670	33	1	4.00	1.89	2.99	3.00	0.000450	0.45
5839.670		10	15.00	1.89	3.82	3.85	0.000624	0.75
5839.670		100	30.00	1.89	4.12	4.18	0.001075	1.13
5583.500	32	1	4.00	1.65	2.90	2.90	0.000305	0.38
5583.500		10	15.00	1.65	3.70	3.72	0.000395	0.61
5583.500		100	30.00	1.65	3.94	3.97	0.000592	0.83
5350.593	31	1	4.00	1.51	2.83	2.84	0.000233	0.35
5350.593		10	15.00	1.51	3.66	3.67	0.000115	0.36
5350.593		100	30.00	1.51	3.92	3.92	0.000086	0.34
5137.441	30	1	4.00	1.50	2.78	2.79	0.000260	0.36
5137.441		10	15.00	1.50	3.64	3.64	0.000124	0.36
5137.441		100	30.00	1.50	3.90	3.90	0.000074	0.31
4941.396	29	1	4.00	1.55	2.72	2.73	0.000376	0.41
4941.396		10	15.00	1.55	3.60	3.61	0.000282	0.55
4941.396		100	30.00	1.55	3.88	3.88	0.000112	0.39
4814.495	28	1	4.00	1.54	2.67	2.68	0.000373	0.40
4814.495		10	15.00	1.54	3.57	3.58	0.000196	0.46
4814.495		100	30.00	1.54	3.87	3.87	0.000081	0.33
4656.597	27	1	4.00	1.41	2.62	2.62	0.000329	0.39
4656.597		10	15.00	1.41	3.51	3.53	0.000390	0.62
4656.597		100	30.00	1.41	3.83	3.85	0.000398	0.71
4422.628	26	1	4.00	1.31	2.53	2.54	0.000374	0.40
4422.628		10	15.00	1.31	3.44	3.45	0.000292	0.52
4422.628		100	30.00	1.31	3.80	3.81	0.000079	0.32
4251.505	25	1	4.00	1.32	2.47	2.48	0.000352	0.40
4251.505		10	15.00	1.32	3.38	3.39	0.000376	0.62
4251.505		100	30.00	1.32	3.79	3.79	0.000092	0.36
4153.203	24	1	4.00	1.26	2.43	2.44	0.000425	0.43
4153.203		10	15.00	1.26	3.35	3.36	0.000333	0.56
4153.203		100	30.00	1.26	3.78	3.78	0.000066	0.30
3923.292	23	1	4.00	1.06	2.37	2.37	0.000231	0.35
3923.292		10	15.00	1.06	3.28	3.29	0.000253	0.52
3923.292		100	30.00	1.06	3.77	3.77	0.000052	0.28

TABLE A.1 HEC-RAS Results for Existing Conditions, Clyde Creek
(Results downstream of XS 30 are preliminary only, used to assess control levels at Manks Rd, and are subject to revision.)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
3679.516	22	1	4.00	1.15	2.29	2.30	0.000420	0.43
3679.516		10	15.00	1.15	3.18	3.20	0.000532	0.68
3679.516		100	30.00	1.15	3.75	3.75	0.000096	0.37
3528.935	21	1	4.00	1.05	2.21	2.22	0.000605	0.50
3528.935		10	15.00	1.05	3.07	3.11	0.000783	0.81
3528.935		100	30.00	1.05	3.73	3.74	0.000149	0.44
3428.823	20	1	4.00	0.97	2.14	2.15	0.000847	0.48
3428.823		10	15.00	0.97	3.02	3.04	0.000526	0.63
3428.823		100	30.00	0.97	3.68	3.71	0.000535	0.79
3425	Lynes Road		Bridge					
3416.118	19	1	4.00	1.11	2.13	2.14	0.000478	0.41
3416.118		10	15.00	1.11	3.01	3.03	0.000448	0.61
3416.118		100	30.00	1.11	3.66	3.69	0.000470	0.78
3285.643	18	1	4.00	0.96	2.04	2.06	0.000765	0.52
3285.643		10	15.00	0.96	2.92	2.95	0.000705	0.78
3285.643		100	30.00	0.96	3.58	3.62	0.000587	0.93
3207.160	17	1	4.00	0.80	2.00	2.01	0.000484	0.47
3207.160		10	15.00	0.80	2.86	2.90	0.000708	0.81
3207.160		100	30.00	0.80	3.50	3.57	0.000815	1.11
3076.148	16	1	4.00	0.76	1.94	1.95	0.000386	0.41
3076.148		10	15.00	0.76	2.79	2.81	0.000539	0.71
3076.148		100	30.00	0.76	3.43	3.47	0.000554	0.92
2953.436	15	1	4.00	0.73	1.90	1.91	0.000346	0.41
2953.436		10	15.00	0.73	2.71	2.74	0.000619	0.75
2953.436		100	30.00	0.73	3.35	3.40	0.000693	1.00
2821.035	14	1	4.00	0.68	1.85	1.86	0.000375	0.46
2821.035		10	15.00	0.68	2.63	2.66	0.000592	0.81
2821.035		100	30.00	0.68	3.25	3.30	0.000693	1.08
2709.483	13	1	4.00	0.52	1.80	1.81	0.000483	0.54
2709.483		10	15.00	0.52	2.56	2.60	0.000544	0.88
2709.483		100	30.00	0.52	3.18	3.24	0.000536	1.14
2640.075	12	1	4.00	0.28	1.78	1.78	0.000338	0.38
2640.075		10	15.00	0.28	2.54	2.56	0.000355	0.61
2640.075		100	30.00	0.28	3.16	3.20	0.000409	0.80
2583.953	11	1	4.00	0.53	1.76	1.76	0.000393	0.41
2583.953		10	15.00	0.53	2.53	2.55	0.000236	0.52
2583.953		100	30.00	0.53	3.16	3.18	0.000197	0.63
2580	Sth Gipps Hwy		Bridge					

TABLE A.1 HEC-RAS Results for Existing Conditions, Clyde Creek
(Results downstream of XS 30 are preliminary only, used to assess control levels at Manks Rd, and are subject to revision.)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
2505.624	10	1	4.00	0.28	1.72	1.73	0.000287	0.38
2505.624		10	15.00	0.28	2.51	2.52	0.000228	0.50
2505.624		100	30.00	0.28	3.14	3.15	0.000206	0.60
2248.790	9	1	4.00	0.36	1.58	1.60	0.001116	0.66
2248.790		10	15.00	0.36	2.35	2.40	0.001046	0.97
2248.790		100	30.00	0.36	2.96	3.03	0.001066	1.24
1946.698	8	1	4.00	0.18	1.33	1.35	0.000645	0.64
1946.698		10	15.00	0.18	2.08	2.13	0.000794	0.98
1946.698		100	30.00	0.18	2.66	2.74	0.000914	1.27
1590.970	7	1	4.00	-0.16	1.16	1.17	0.000388	0.52
1590.970		10	15.00	-0.16	1.79	1.84	0.000866	0.98
1590.970		100	30.00	-0.16	2.32	2.40	0.000980	1.27
1265.320	6	1	4.00	-0.19	1.08	1.09	0.000193	0.45
1265.320		10	15.00	-0.19	1.58	1.63	0.000538	0.94
1265.320		100	30.00	-0.19	2.07	2.16	0.000663	1.27
1004.420	5	1	4.00	-0.31	1.05	1.05	0.000100	0.35
1004.420		10	15.00	-0.31	1.47	1.50	0.000404	0.83
1004.420		100	30.00	-0.31	1.92	1.99	0.000558	1.17
781.9454	4	1	4.00	-0.37	1.02	1.03	0.000108	0.35
781.9454		10	15.00	-0.37	1.36	1.40	0.000525	0.90
781.9454		100	30.00	-0.37	1.77	1.85	0.000741	1.27
435.7517	3	1	4.00	-0.66	1.00	1.01	0.000040	0.29
435.7517		10	15.00	-0.66	1.22	1.26	0.000309	0.88
435.7517		100	30.00	-0.66	1.54	1.63	0.000564	1.32
201.1384	2	1	4.00	-0.97	1.00	1.00	0.000017	0.20
201.1384		10	15.00	-0.97	1.19	1.21	0.000139	0.61
201.1384		100	30.00	-0.97	1.48	1.52	0.000278	0.95
0	1	1	4.00	-1.10	1.00	1.00	0.000001	0.05
0		10	15.00	-1.10	1.20	1.20	0.000006	0.17
0		100	30.00	-1.10	1.50	1.50	0.000014	0.29

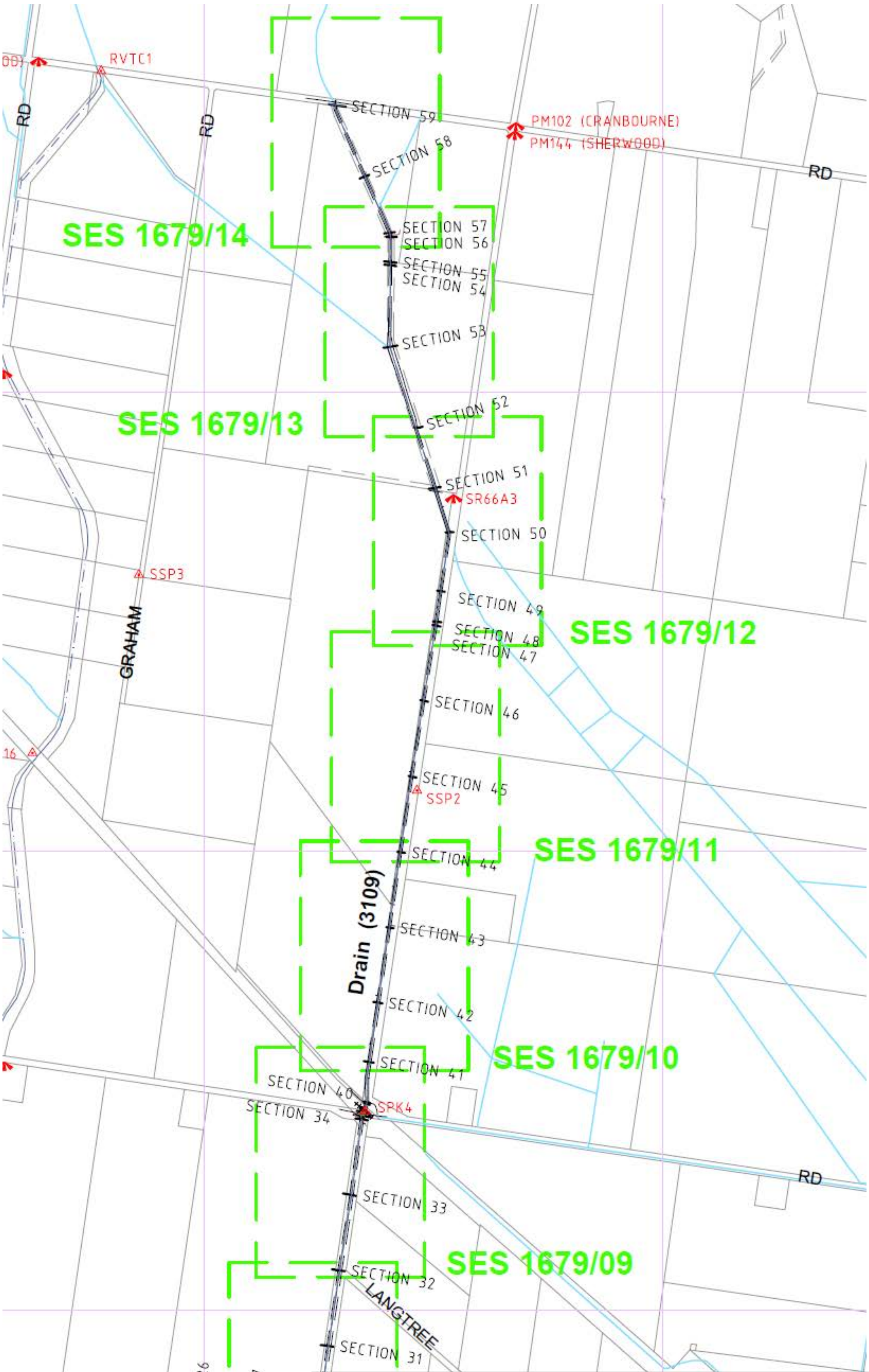
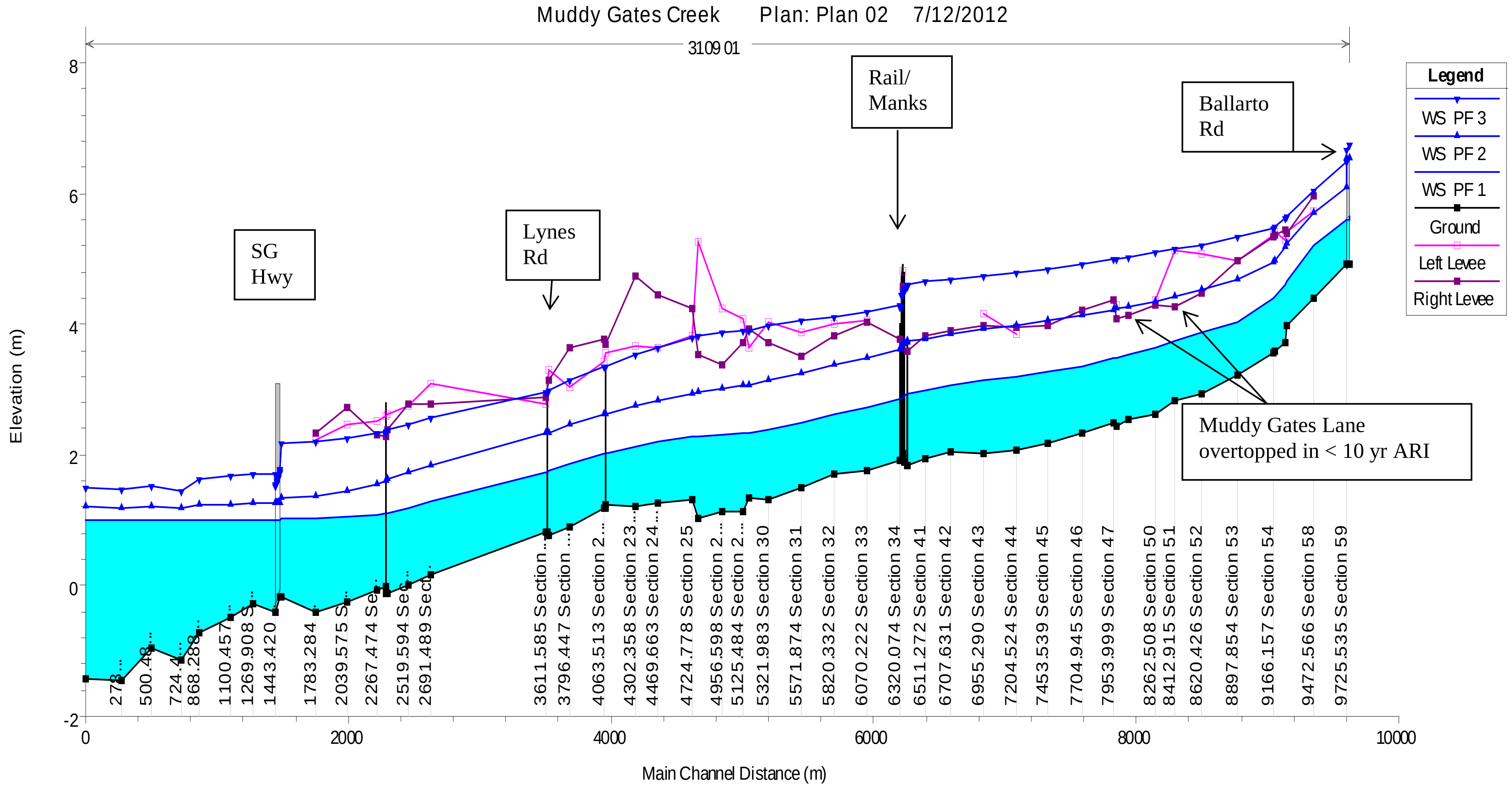
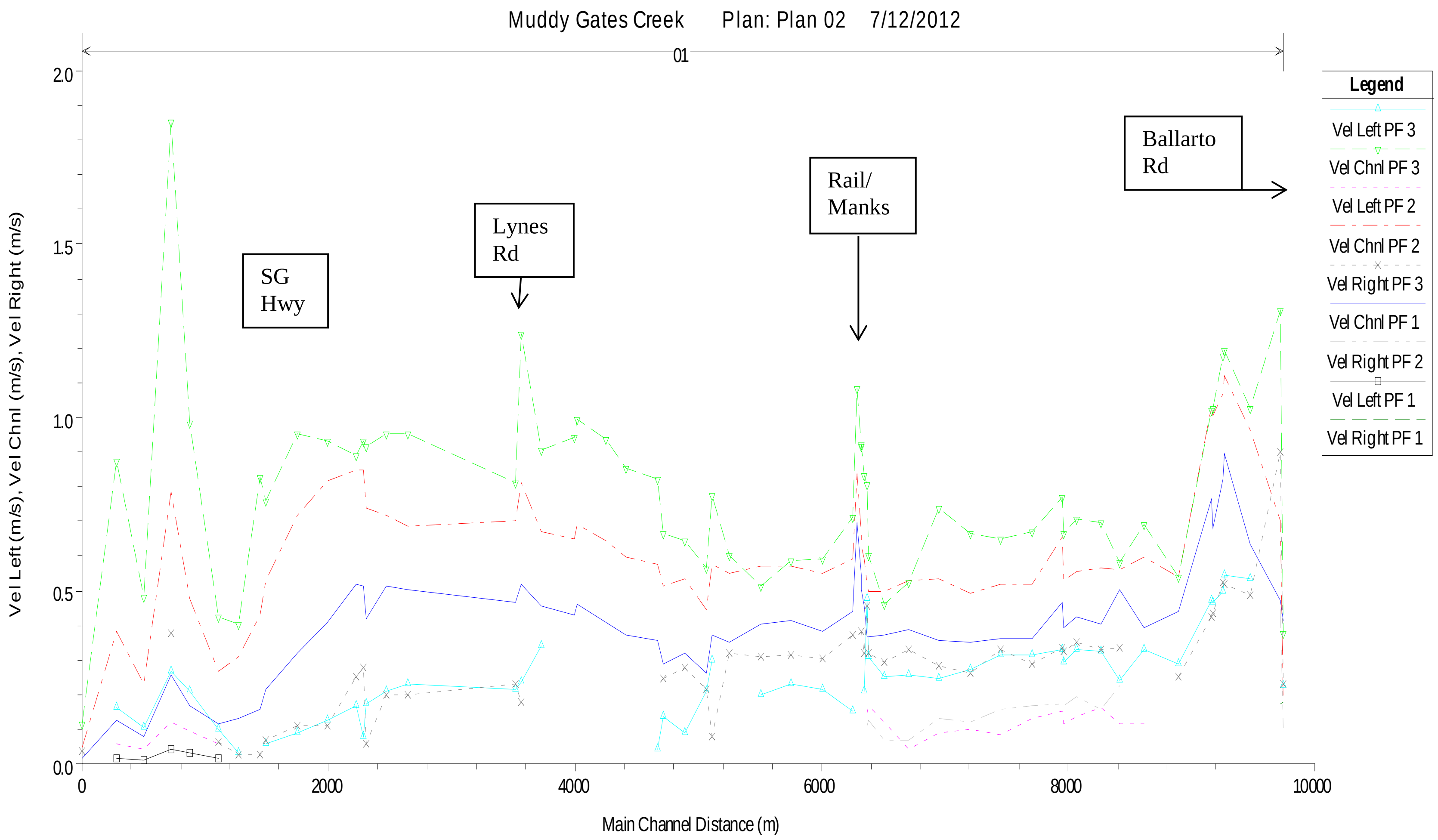


Figure A.7
MW Survey Sections along Muddy Gates Creek



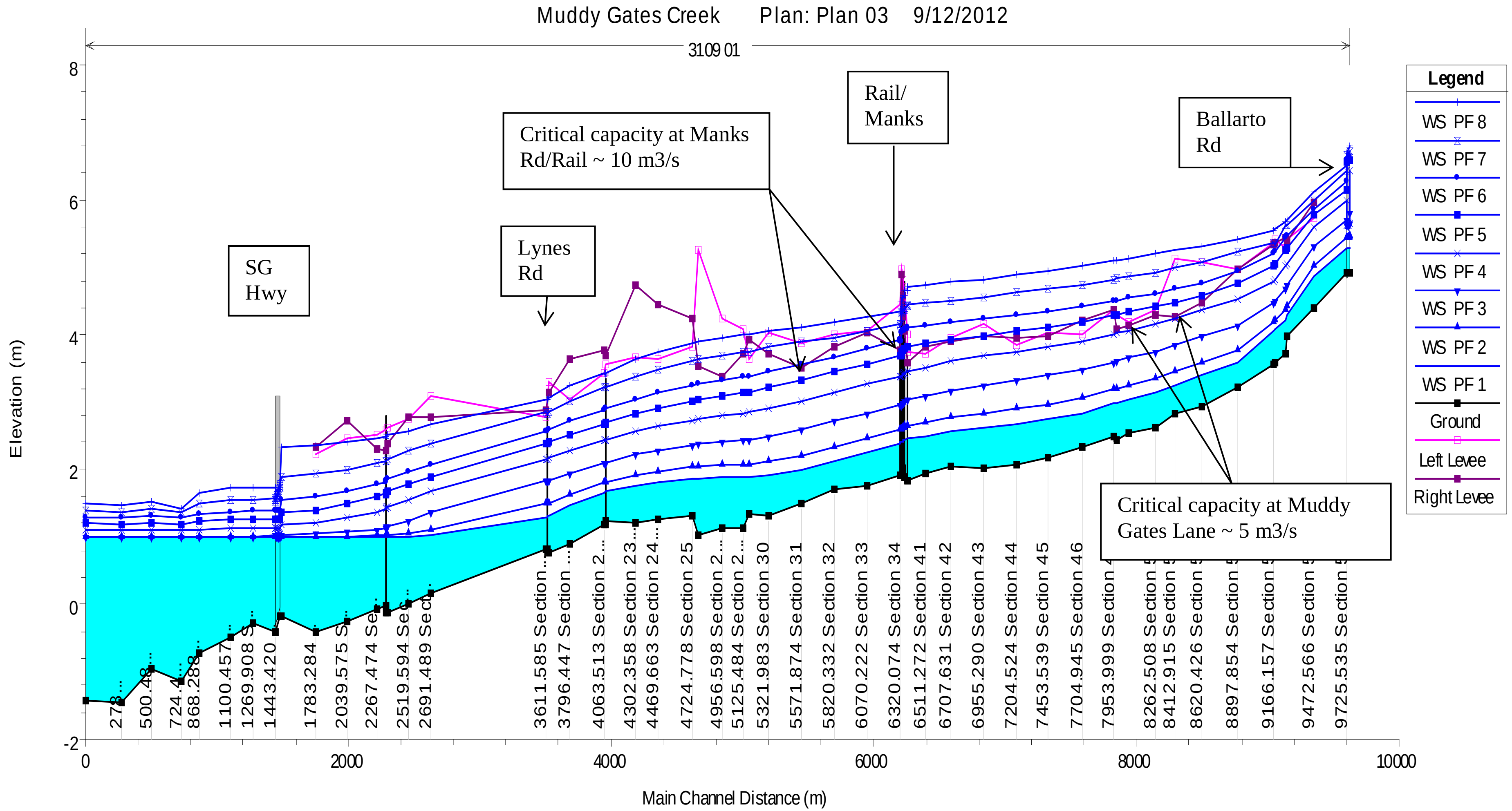
Notes: PF1=1 year ARI, PF2=10 yr ARI, PF3=100 yr ARI. Refer to Table A.2 for results at each Section (XS). Results above confining levees are hypothetical.

Figure A.8
1, 10, 100 year ARI Flood profiles, Muddy Gates Creek



Notes: PF1=1 year ARI, PF2=10 yr ARI, PF3=100 yr ARI. Refer to Table A.2 for results at each Section (XS).
(Note: results above confining levees are hypothetical)

Figure A.9
1, 10, 100 year ARI Flood velocities, Muddy Gates Creek



Profiles for 20, 15, 10, 7.5, 5, 2.5, 1 and 0.5 m3/s respectively, for threshold capacity checks
(Note: profiles above confining levees are hypothetical)

Figure A.10
Trial flow profiles, Muddy Gates Creek

TABLE A.2 HEC-RAS Results for Existing Conditions, Muddy Gates Creek
(Note: Results above confining levees are hypothetical)

Station	XS	ARI	Flow	Invert	Water level	Energy Level	Energy Slope	Channel Velocity
		(yrs)	(m3/s)	(m)	(m)	(m)	(m/m)	(m/s)
9745	60	1	1.80	4.91	5.65	5.65	0.000836	0.41
9745		10	6.10	4.91	6.55	6.55	0.000034	0.17
9745		100	16.50	4.91	6.75	6.76	0.000133	0.38
9742	Ballarto Road		Culvert					
9725.535	59	1	1.80	4.91	5.60	5.61	0.001256	0.47
9725.535		10	6.10	4.91	6.08	6.11	0.000959	0.70
9725.535		100	16.50	4.91	6.48	6.56	0.002012	1.31
9472.566	58	1	1.80	4.39	5.21	5.23	0.001792	0.64
9472.566		10	6.10	4.39	5.70	5.75	0.002235	0.96
9472.566		100	16.50	4.39	6.05	6.08	0.001629	1.02
9271.615	57	1	2.00	3.98	4.65	4.69	0.004111	0.89
9271.615		10	6.70	3.98	5.22	5.29	0.003226	1.12
9271.615		100	18.00	3.98	5.65	5.70	0.002185	1.19
9256.506	56	1	2.00	3.73	4.60	4.63	0.003191	0.82
9256.506		10	6.70	3.73	5.18	5.24	0.002866	1.07
9256.506		100	18.00	3.73	5.62	5.67	0.002007	1.18
9175.290	55	1	2.00	3.60	4.41	4.44	0.001838	0.68
9175.290		10	6.70	3.60	4.98	5.03	0.002190	1.00
9175.290		100	18.00	3.60	5.48	5.52	0.001598	1.03
9166.157	54	1	2.00	3.56	4.39	4.42	0.002801	0.77
9166.157		10	6.70	3.56	4.96	5.01	0.002460	1.03
9166.157		100	18.00	3.56	5.47	5.51	0.001432	1.02
8897.854	53	1	2.00	3.21	4.04	4.05	0.000799	0.44
8897.854		10	6.70	3.21	4.69	4.70	0.000623	0.54
8897.854		100	18.00	3.21	5.33	5.34	0.000332	0.54
8620.426	52	1	2.00	2.93	3.87	3.88	0.000477	0.39
8620.426		10	6.70	2.93	4.52	4.54	0.000561	0.60
8620.426		100	18.00	2.93	5.22	5.23	0.000422	0.69
8412.915	51	1	2.00	2.82	3.73	3.75	0.000861	0.50
8412.915		10	6.70	2.82	4.42	4.43	0.000495	0.56
8412.915		100	18.00	2.82	5.15	5.16	0.000271	0.58
8262.508	50	1	2.00	2.61	3.64	3.65	0.000482	0.40
8262.508		10	6.70	2.61	4.34	4.36	0.000426	0.56
8262.508		100	18.00	2.61	5.10	5.12	0.000344	0.70
8067.812	49	1	2.00	2.55	3.54	3.55	0.000561	0.43
8067.812		10	6.70	2.55	4.27	4.28	0.000365	0.56
8067.812		100	18.00	2.55	5.03	5.05	0.000319	0.70
7966.734	48	1	2.00	2.45	3.49	3.50	0.000453	0.39
7966.734		10	6.70	2.45	4.23	4.25	0.000370	0.53

TABLE A.2 HEC-RAS Results for Existing Conditions, Muddy Gates Creek (Note: Results above confining levees are hypothetical)								
Station	**XS**	**ARI**	**Flow**	**Invert**	**Water level**	**Energy Level**	**Energy Slope**	**Channel Velocity**
		(yrs)	**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m/m)**	**(m/s)**
7966.734		100	18.00	2.45	5.00	5.02	0.000306	0.67
7953.999	47	1	2.00	2.48	3.48	3.49	0.000688	0.47
7953.999		10	6.70	2.48	4.22	4.24	0.000556	0.66
7953.999		100	18.00	2.48	4.99	5.01	0.000403	0.77
7704.945	46	1	2.00	2.34	3.36	3.37	0.000371	0.36
7704.945		10	6.70	2.34	4.13	4.14	0.000297	0.52
7704.945		100	18.00	2.34	4.91	4.93	0.000272	0.67
7453.539	45	1	2.00	2.17	3.27	3.28	0.000338	0.36
7453.539		10	6.70	2.17	4.05	4.06	0.000311	0.52
7453.539		100	18.00	2.17	4.85	4.86	0.000263	0.65
7204.524	44	1	2.00	2.08	3.20	3.20	0.000261	0.35
7204.524		10	6.70	2.08	3.99	4.00	0.000204	0.49
7204.524		100	18.00	2.08	4.79	4.81	0.000206	0.66
6955.290	43	1	2.00	2.03	3.13	3.14	0.000239	0.36
6955.290		10	6.70	2.03	3.93	3.94	0.000246	0.53
6955.290		100	18.00	2.03	4.73	4.75	0.000260	0.74
6707.631	42	1	2.00	2.04	3.06	3.06	0.000419	0.39
6707.631		10	6.70	2.04	3.85	3.86	0.000422	0.53
6707.631		100	18.00	2.04	4.68	4.69	0.000198	0.52
6511.272	41	1	2.00	1.94	2.98	2.98	0.000392	0.37
6511.272		10	6.80	1.94	3.78	3.79	0.000352	0.50
6511.272		100	18.10	1.94	4.65	4.65	0.000144	0.46
6378.890	40	1	2.00	1.84	2.93	2.93	0.000376	0.37
6378.890		10	6.80	1.84	3.73	3.74	0.000323	0.50
6378.890		100	18.10	1.84	4.62	4.63	0.000230	0.60
6378	McAlpine Road		Bridge					
6374.121	39	1	2.00	1.83	2.92	2.93	0.000374	0.37
6374.121		10	6.80	1.83	3.72	3.74	0.000358	0.52
6374.121		100	18.10	1.83	4.58	4.61	0.000427	0.81
6352.943	38	1	2.00	1.90	2.91	2.92	0.000535	0.46
6352.943		10	6.80	1.90	3.71	3.73	0.000411	0.59
6352.943		100	18.10	1.90	4.56	4.60	0.000439	0.83
6352	Rail		Bridge					
6347.070	37	1	2.00	1.93	2.89	2.90	0.000667	0.50
6347.070		10	6.80	1.93	3.69	3.71	0.000460	0.63
6347.070		100	18.10	1.93	4.50	4.54	0.000523	0.92
6344.959	36	1	2.00	2.01	2.89	2.90	0.001069	0.54
6344.959		10	6.80	2.01	3.68	3.71	0.000746	0.66

TABLE A.2 HEC-RAS Results for Existing Conditions, Muddy Gates Creek (Note: Results above confining levees are hypothetical)								
Station	**XS**	**ARI**	**Flow**	**Invert**	**Water level**	**Energy Level**	**Energy Slope**	**Channel Velocity**
		(yrs)	**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m/m)**	**(m/s)**
6344.959		100	18.10	2.01	4.49	4.54	0.000859	0.91
6342	Manks Road		Bridge					
6331.493	35	1	2.00	1.92	2.86	2.88	0.001388	0.70
6331.493		10	6.80	1.92	3.65	3.69	0.000977	0.84
6331.493		100	18.10	1.92	4.44	4.50	0.001234	1.08
6330	Lower Manks Road		Bridge					
6320.074	34	1	2.00	1.91	2.86	2.87	0.000623	0.44
6320.074		10	6.80	1.91	3.62	3.64	0.000568	0.59
6320.074		100	18.10	1.91	4.29	4.31	0.000469	0.71
6070.222	33	1	2.00	1.76	2.73	2.74	0.000431	0.38
6070.222		10	6.80	1.76	3.49	3.51	0.000439	0.55
6070.222		100	18.10	1.76	4.20	4.21	0.000302	0.59
5820.332	32	1	2.00	1.70	2.61	2.62	0.000522	0.41
5820.332		10	6.80	1.70	3.38	3.39	0.000501	0.57
5820.332		100	18.10	1.70	4.12	4.13	0.000315	0.59
5571.874	31	1	2.00	1.51	2.49	2.49	0.000468	0.40
5571.874		10	6.80	1.51	3.25	3.27	0.000501	0.57
5571.874		100	18.10	1.51	4.06	4.07	0.000228	0.51
5321.983	30	1	2.00	1.32	2.39	2.40	0.000304	0.35
5321.983		10	6.80	1.32	3.14	3.15	0.000427	0.55
5321.983		100	18.10	1.32	3.98	4.00	0.000332	0.60
5173.636	29	1	2.00	1.35	2.34	2.35	0.000371	0.37
5173.636		10	6.80	1.35	3.07	3.08	0.000498	0.58
5173.636		100	18.10	1.35	3.91	3.94	0.000522	0.77
5125.484	28	1	2.00	1.13	2.34	2.34	0.000115	0.26
5125.484		10	6.80	1.13	3.06	3.07	0.000195	0.45
5125.484		100	18.10	1.13	3.91	3.92	0.000178	0.57
4956.598	27	1	2.00	1.14	2.31	2.32	0.000185	0.32
4956.598		10	6.80	1.14	3.01	3.03	0.000307	0.54
4956.598		100	18.10	1.14	3.87	3.88	0.000250	0.64
4777.932	26	1	2.00	1.02	2.28	2.29	0.000141	0.29
4777.932		10	6.80	1.02	2.96	2.98	0.000273	0.51
4777.932		100	18.10	1.02	3.82	3.84	0.000268	0.66
4724.778	25	1	2.00	1.31	2.27	2.28	0.000272	0.36
4724.778		10	6.80	1.31	2.94	2.96	0.000370	0.57
4724.778		100	18.10	1.31	3.78	3.82	0.000497	0.82
4469.663	24	1	2.00	1.26	2.20	2.20	0.000324	0.37

TABLE A.2 HEC-RAS Results for Existing Conditions, Muddy Gates Creek (Note: Results above confining levees are hypothetical)								
Station	**XS**	**ARI**	**Flow**	**Invert**	**Water level**	**Energy Level**	**Energy Slope**	**Channel Velocity**
		(yrs)	**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m/m)**	**(m/s)**
4469.663		10	6.80	1.26	2.84	2.86	0.000428	0.60
4469.663		100	18.10	1.26	3.65	3.68	0.000561	0.85
4302.358	23	1	2.00	1.21	2.13	2.14	0.000421	0.41
4302.358		10	6.80	1.21	2.76	2.78	0.000515	0.64
4302.358		100	18.10	1.21	3.53	3.58	0.000709	0.94
4071.854	22	1	2.00	1.24	2.01	2.02	0.000626	0.46
4071.854		10	6.80	1.24	2.62	2.65	0.000650	0.69
4071.854		100	18.10	1.24	3.35	3.40	0.000834	0.99
4069	Farm Crossing		Bridge					
4063.513	21	1	2.00	1.18	2.01	2.02	0.000519	0.43
4063.513		10	6.80	1.18	2.62	2.64	0.000559	0.65
4063.513		100	18.10	1.18	3.34	3.39	0.000754	0.94
3796.447	20	1	2.00	0.89	1.85	1.86	0.000668	0.46
3796.447		10	6.80	0.89	2.46	2.48	0.000618	0.67
3796.447		100	18.10	0.89	3.15	3.19	0.000701	0.90
3626.546	19	1	2.00	0.76	1.75	1.76	0.000535	0.52
3626.546		10	6.80	0.76	2.34	2.38	0.000694	0.81
3626.546		100	18.10	0.76	2.97	3.05	0.000948	1.24
3624	Lynes Road		Bridge					
3611.585	18	1	2.00	0.83	1.74	1.75	0.000452	0.46
3611.585		10	6.80	0.83	2.32	2.35	0.000526	0.70
3611.585		100	18.10	0.83	2.97	2.99	0.000363	0.81
2691.489	17	1	2.00	0.16	1.28	1.29	0.000610	0.50
2691.489		10	6.80	0.16	1.85	1.87	0.000567	0.69
2691.489		100	18.10	0.16	2.56	2.61	0.000529	0.96
2519.594	16	1	2.00	0.02	1.18	1.19	0.000582	0.51
2519.594		10	6.80	0.02	1.74	1.77	0.000698	0.72
2519.594		100	18.10	0.02	2.47	2.52	0.000557	0.95
2340.300	15	1	2.00	-0.12	1.11	1.12	0.000282	0.42
2340.300		10	6.80	-0.12	1.62	1.65	0.000687	0.74
2340.300		100	18.10	-0.12	2.38	2.42	0.000587	0.92
2338	Farm Crossing		Bridge					
2334.159	14	1	2.00	-0.01	1.10	1.11	0.000476	0.51
2334.159		10	6.80	-0.01	1.59	1.63	0.001086	0.85
2334.159		100	18.10	-0.01	2.35	2.39	0.000637	0.93
2267.474	13	1	2.00	-0.08	1.08	1.09	0.000238	0.52
2267.474		10	6.80	-0.08	1.55	1.58	0.000508	0.85
2267.474		100	18.10	-0.08	2.33	2.37	0.000250	0.89

TABLE A.2 HEC-RAS Results for Existing Conditions, Muddy Gates Creek (Note: Results above confining levees are hypothetical)								
Station	**XS**	**ARI**	**Flow**	**Invert**	**Water level**	**Energy Level**	**Energy Slope**	**Channel Velocity**
		(yrs)	**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m/m)**	**(m/s)**
2039.575	12	1	2.00	-0.26	1.05	1.05	0.000115	0.41
2039.575		10	6.80	-0.26	1.45	1.48	0.000402	0.82
2039.575		100	18.10	-0.26	2.27	2.31	0.000250	0.93
1783.284	11	1	2.00	-0.40	1.03	1.03	0.000063	0.32
1783.284		10	6.80	-0.40	1.37	1.40	0.000259	0.72
1783.284		100	18.10	-0.40	2.21	2.25	0.000210	0.95
1488.128	10	1	2.00	-0.18	1.02	1.02	0.000023	0.22
1488.128		10	6.80	-0.18	1.34	1.36	0.000107	0.53
1488.128		100	18.10	-0.18	2.18	2.21	0.000119	0.76
1483	Sth Gipps Hwy		Culvert					
1443.420	9	1	2.00	-0.40	1.01	1.01	0.000010	0.16
1443.420		10	6.80	-0.40	1.26	1.27	0.000063	0.43
1443.420		100	18.10	-0.40	1.70	1.74	0.000174	0.83
1269.908	8	1	2.00	-0.28	1.01	1.01	0.000012	0.13
1269.908		10	6.80	-0.28	1.25	1.26	0.000066	0.31
1269.908		100	18.10	-0.28	1.70	1.71	0.000115	0.40
1100.457	7	1	2.00	-0.48	1.01	1.01	0.000012	0.12
1100.457		10	6.80	-0.48	1.25	1.25	0.000039	0.27
1100.457		100	18.10	-0.48	1.68	1.69	0.000055	0.43
868.2882	6	1	2.00	-0.73	1.00	1.00	0.000010	0.17
868.2882		10	6.80	-0.73	1.23	1.24	0.000067	0.48
868.2882		100	18.10	-0.73	1.62	1.67	0.000217	0.99
724.4187	5	1	2.00	-1.14	1.00	1.00	0.000013	0.26
724.4187		10	6.80	-1.14	1.19	1.22	0.000104	0.78
724.4187		100	18.10	-1.14	1.45	1.61	0.000498	1.85
500.4849	4	1	2.00	-0.95	1.00	1.00	0.000003	0.08
500.4849		10	6.80	-0.95	1.21	1.21	0.000017	0.23
500.4849		100	18.10	-0.95	1.52	1.54	0.000056	0.48
278.5606	3	1	2.00	-1.46	1.00	1.00	0.000004	0.13
278.5606		10	6.80	-1.46	1.20	1.20	0.000034	0.38
278.5606		100	18.10	-1.46	1.48	1.51	0.000151	0.88
0	1	1	2.00	-1.43	1.00	1.00	0.000000	0.02
0		10	6.80	-1.43	1.20	1.20	0.000000	0.05
0		100	18.10	-1.43	1.50	1.50	0.000002	0.11