5 MILE BROOK DIVERSION DRAIN – NORTH ARM
PROPOSED IMPLEMENTATION PLAN
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1 INTRODUCTION

1.1 Purposes of this Report

The purposes of this report are:-

i) To provide a report in which the principles for implementation of the 5MBDD – North Arm are documented and subsequently agreed by the following organisations;

- Shire of Capel
- City of Bunbury
- Department of Water (DoW)
- Water Corporation
- Western Australian Planning Commission (WAPC)
- Satterley Property Group and Ironbridge as the major developing landowners within the East Dalyellup Structure Plan Area

ii) To outline the respective responsibilities of the above organisations after it is agreed by all to proceed with implementation of the 5MBDD – North Arm works.

1.2 Background

The Five Mile Brook is located on a flat coastal plain between Capel and Bunbury. The upstream catchment extends east from Bussell Highway and encompasses a catchment area of approximately 40km² (Five Mile Brook Diversion Drain: Review, JDA February 2006). In order to alleviate flooding of the Bunbury area, the Five Mile Brook Diversion Drain (5MBDD) was constructed by the Public Work’s Department in the 1960’s. This diversion drain commences at Bussell Highway and runs in a south westerly direction before discharging into the ocean.

The Waters and Rivers Commission conducted a flood study in 2003 to assess whether the 100 year flow could be conveyed through the 5MBDD. The report estimates the 10, 25 and 100 year ARI flows from the Five Mile Brook at Bussell Highway to be 15, 20 and 25 m³/sec respectively. JDA have conducted separate modelling of the upstream catchment and concur with the Waters and Rivers report that the 100 year peak flow from the Five Mile Brook at Bussell Highway is 25m³/s (JDA Review of 100 year ARI Flow Estimate, Letter reference J3695r).

Hydraulic modelling of the 5MBDD downstream of Bussell Highway by Waters and Rivers Commission and by JDA has deduced that the existing culverts under Bussell Highway are unable to convey the 100 year peak flow of 25m³/s due to the high tailwater level downstream. The culverts were estimated to convey 18m³/s with the remaining 100 year peak flow of 7m³/s estimated to flow in a northerly direction. The potential for this flow to cross Bussell Highway and inundate landholdings within the East Dalyellup Structure Plan area has led to investigations by both the Water Corporation and the major developers at East Dalyellup to determine the most effective form of flood protection for the proposed urban development. An aerial photograph of East Dalyellup is included in Appendix A of this report. This illustrates the site vegetation, areas of existing filling and the locations of roads and topographical features described in this report.

The first option investigated was the upgrading of the 5MBDD to enable the 100yr peak flow of 25m³/s to be conveyed. The results of this investigation are described in the Water Corporation
Report (Five Mile Brook Diversion Drain, October 2004). The report recommends the following upgrades;

- Widen the base of the 5MBDD to 6m between Minninup Road and Bussell Highway (a length of approximately 4.2 kms). The base width of the 5MBDD currently varies between 3 and 4m wide.
- Construct a 1m drop structure at the downstream end of Harewoods Road Culvert.
- Upgrade the culverts at Bussell Highway by constructing an additional 2/1800 mm diameter pipes under both carriageways.
- Construct approximately 350m of new levee banks and depending on geotechnical investigations on the existing levee banks possibly another 750m of further levee banks.

An alternative option for providing flood protection to East Dalyellup is to provide a major overland flow path through the East Dalyellup development that conveys the $7m^3/s$ overflow from the Bussell Highway culverts. This option was initially explored by Dalyellup Beach Pty Ltd in August 2006 whereby a temporary overland flow path was modelled through East Dalyellup with the aim of providing an overland flow route through the development until such time the 5MBDD upgrades were agreed. The Department of Water (DoW) subsequently reviewed the proposal and then suggested that this option be further investigated to see if it could be implemented as a permanent solution rather than pursue expensive upgrades to the 5MBDD. (Department of Water letter, 11 September 2006, Ref 6403).

In response to the DoW's suggestion that the $7m^3/s$ flow be conveyed in a northerly direction, JDA conducted modelling of the permanent overland flow path commencing downstream of the Bussell Highway culverts and extending north until Washington Avenue. JDA's report has been included as Appendix B (JDA Report, ref J3773P).

2 OVERLAND FLOW PATH OVERVIEW

2.1 Outline of Permanent Overland Flood Route

The overland flow path, which is required to convey a peak flow of $7m^3/sec$, is shown diagrammatically in Appendix C. This overland flow channel is referred to as 5MBDD – North Arm in the text. In addition to the drawing, a description of the proposed overland flow path is described below;

- The Five Mile Brook 100 year peak flow of $25m^3/s$ is currently unable to pass through the culverts under Bussell Highway. The remaining floodwaters build up on the east side of Bussell Highway. This mechanism will be unaltered with the permanent solution.
- The overflow will cross the southbound carriageway at the low point just north of the culverts and flows into the Bussell Highway median where after it flows north. This is also consistent with current arrangements.
- The Bussell Highway median soon becomes higher that the northbound carriageway and currently forces the overflow out of the median and onto the northbound carriageway.
- After leaving the median the overflow continues to run in a northerly direction along the northbound carriageway which effectively acts as a channel since the western verge and median are both higher than the carriageway. The water then flows off the northbound carriageway and into the Riding School for the Disabled (RDA) land just south of the future intersection of Parade Road and Bussell Highway. It then flows north along the edge of Bussell Highway until it reaches the proposed Parade Road.
• The permanent works essentially start at Parade Road with the overflow to be piped under the future Parade Road by a series of culverts. Preliminary modelling by JDA has determined the size of the culverts to be 3/1050mm diameter.

• The overflow will run north along a formed channel or swale. The eastern edge of the channel is formed by the Bussell Highway northbound carriageway (allowing 20m for widening) and the western edge is formed by filling of the East Dalyellup land. The western edge of the channel is modelled 20m inside the Dalyellup East boundary with a 1:6 batter to the base.

• The overflow is to be piped under the existing Norton Promenade by a series of culverts. Preliminary modelling by JDA has determined the size of the culverts to be 3/1050mm diameter.

• The overflow will continue north along a formed channel, same as described above.

• Just prior to reaching the northern boundary of Lot 4, the channel will turn west and run along the northern boundary of Lot 4. The channel at this point has been modelled 20m wide at the top with 1:6 side slopes down to the base.

• The channel will turn north again and either run through Ironbridge landholdings or straddle the boundary of Ironbridge and the lot owners to the east (subject to further assessment) until it reaches Centenary Road.

• The overflow will be piped under the existing Centenary Road by a series of newly constructed culverts. Preliminary modelling by JDA has determined the size of the culverts to be 2/1050mm diameter.

• The overland flow will discharge into the Regional Open Space (ROS) area illustrated on the Tuart Brook Concept Plan (Appendix E). This depressed area currently acts and will continue to act as a compensating basin to attenuate flow.

• The flow will exit under Washington Avenue through a new 1050mm diameter culvert which will replace the existing 1500mm diameter culvert. The proposed flow of 2m³/s will match the pre-development flow as required by the DoW.

2.2 Outline of Interim Overland Flood Route

There are four different landowners within the East Dalyellup Structure Plan area. Each of their respective landholdings will be developed at different times and therefore an interim overland flood route through East Dalyellup is necessary to ensure that an overland flow path is maintained at all times during the development. The interim overland flow path is shown diagrammatically in Appendix D. In addition to the drawing, a description of the proposed interim overland flow path is described below;

• The mechanics of the 100 year overflow from the 5 Mile Brook culverts north until the point where the overflow spills across the northbound carriageway and into the Riding School for Disabled land is identical to the permanent flow path. The flow exists into the RDA land just south of the future Parade Road intersection with Bussell Highway.

• Prior to the construction of Parade Road, the overflow will flow north in the RDA land and survey shows it will generally keep alongside Bussell Highway to the commencement of Morgan’s landholdings.

• Prior to Morgan’s land being filled for development, the overflow will spread across Morgan’s land and flow to the lowest point, that being the north east corner of the site alongside Bussell Highway at the boundary with Dalyellup Beach Estates landholdings. Once Morgan’s land is filled, the overland flow path will be restricted to a 20m corridor alongside the eastern boundary of this site.
• The land between the southern boundary of Dalyellup Beach Estate's land and Norton Promenade has largely been filled apart from a corridor along the eastern edge. This will form the interim flow path whereby the overland flow will travel along this unfilled corridor until Norton Promenade where it will deviate around the current Dalyellup entry statement and flow across Norton Promenade.

• After flowing across Norton Promenade, the overflow will run north in a channel along the eastern edge of Lot 4. The channel will be formed by the filling of Lot 4 for urban development to the west and Bussell Highway to the east.

• At the northern end of Lot 4, the interim flow path will deviate west so that it crosses the boundary into Ironbridge landholdings at the location of the existing rural farmland drain. Should Ironbridge's land not be filled at this point in time, the flow will proceed north to Centenary Road by spreading out over the farming land. Once Ironbridge place fill on this land, the flow will be directed to Centenary Road via a formed channel.

• The overflow will meet Centenary Road at the same location as the existing farmland drain. The existing culvert is unable to pass the 100 year flow and therefore the floodwaters will pass over Centenary Road and into the ROS to the north. From this point the overland flow path is the same as for the permanent arrangement.

2.3 Visual Aspects and Landscaping

It is envisaged that the permanent overland flow channel will have the visual appearance of a landscaped swale with side slopes of 1:6 minimum. The planting will generally consist of ground covers having a height of less than 250mm or reed like vegetation which can be readily bent over during the passage of floodwaters. Vegetation such as shrubs with foliage shall not be installed. Large trees can be planted along the channel batter for screening purposes should they be required (ie along the edge of Bussell Highway). A concept landscaping plan is attached as Appendix E.

2.4 Land Requirements

Where the overland flow channel passes through a developer's landholdings the area to be ceded for the channel will be 20m wide. This allows for the channel to have 1:6 side slopes graded down from the final filled level of the adjacent development. Details of land to be ceded are shown in Appendix G.

2.5 Funding

Each individual land developer within East Dalyellup will be required to fund the construction works allocated to them on the table in Appendix H. The works which are attributed to each developer fall largely on their respective landholdings and the estimated total cost of works to be funded by each developer is in proportion to the size of their landholdings within the East Dalyellup Structure Plan area. The estimated construction costs are based on the alignment of the permanent overflow drainage route as shown in Appendix C of this report and should the alignment be altered through the review process then the work proportioned to each developer would need to be reviewed to ensure an equitable portion of work is attributed to each.

2.6 Environmental Considerations

At the northern boundary of East Dalyellup, the overland flow channel will be piped under Centenary Avenue through a series of culverts such that the 100 year overflow is allowed to discharge into the proposed Regional Open Space (ROS) area between Centenary Road and
Washington Avenue. The ROS consists of a depressed area which acts as a natural compensating basin before the flow exits under Washington Avenue. The “pre development” 100-year flood level upstream of Washington Avenue was calculated by the Water Authority as being 5.10 m AHD.

The post development 100 year water level in the ROS area has been modelled by JDA and has been limited to 5.10m AHD to match “pre existing” conditions. As such, the impact on the surrounding environment in the ROS is unaltered.

Downstream of Washington Avenue the “post development” flow matches the estimated “pre development” flow of 2m3/s and therefore there are no adverse impacts on the environment. The existing flow path remains unchanged.

On this basis, there will be minimal alteration to the existing conditions and subsequently no adverse environmental impacts as a result of the proposal.

3. IMPLEMENTATION PRINCIPLES

The following implementation principles will apply:-

i) The mechanism for gaining approvals for construction of each phase of the overland flow route will be via the relevant statutory agencies through the development approval process and conditions of subdivision.

ii) Until such time all of the proposed 5MBDD – North Arm works are completed, a route that permits the passage of flood waters should be available at all times. This “interim flood route” is described in Section 2.2 above.

iii) Following agreement by the organisations mentioned in Section 1.1 to implement construction of the 5MBDD – North Arm, each organisation will have certain responsibilities which are to be complied with. These are detailed in Section 4 and summarised in the table in Section 5.

iv) Each individual land developer within East Dalyellup will be required to fund the construction works allocated to them on the table in Appendix H.

v) Each land developer may install infrastructure required to implement the proposed 5MBDD – North Arm works in parallel with on-going subdivision and development.

4. SCOPE OF WORKS

Cossill & Webley, in conjunction with JDA, have identified that the following works are required to implement the 5MBDD – North Arm works.

4.1 Design Tasks

1) Preparation of Drainage Design Report

The work carried out by JDA to date is extensive and clearly demonstrates construction of the 5MBDD – North Arm is a viable solution to dealing with flooding matters.

However, it is still necessary for JDA to produce a report which clearly specifies the full extent and details of the works to be built. This includes documentation of culvert diameters, invert levels, cross-sections, landscape treatments and the like.

JDA’s “Design Report” would form the basis for construction of the works which is likely to be done in stages by different parties. It will outline the “interim” and “permanent” flow paths and describe when various components of the drain are required to be built.

Responsibility for this task rests with Satterley Property Group and Ironbridge.
(2) **Preparation of Detailed Design Drawings and securing of construction works approval**
Responsibility for this task rests with **Satterley Property Group and Ironbridge**.

### 4.2 Construction Works

(3) **Throttling of existing Washington Avenue Culvert**
It will be necessary to reduce the diameter of the existing culvert under Washington Avenue from 1500mm to 1050mm to avoid increasing downstream peak flows.
Responsibility for this task rests with **Ironbridge**.

(4) **Construction of new Culverts under Centenary Road**
These culverts (2 x 1050mm) should operate independently of the existing culverts which have a function to restrict flows generated from proposed development south of Centenary Road (Dalyellup Beach Estate, Ironbridge, etc) to pre-development flows.
Responsibility for this task rests with **Ironbridge**.

(5) **Ceding of 20m wide strip of Land to the Shire of Capel (refer details shown on Appendix G)**
Responsibility for this task rests with the **respective Developers** on which the land falls.

(6) **Formation of a new drain including clearing, earthworking, shaping and landscaping.**
It is noted that in most cases the drain will be formed as a result of filling adjacent to land to be ceded for drainage. Each developer is responsible for ensuring that the agreed overland flow path on their land remains clear at all times and is not filled. Using this approach, land at East Dalyellup can be developed at various times whilst still maintaining a flow path for the 100 year overflow event.
Responsibility for this task rests with the **respective Developers** on which the land falls.

(7) **Construction of new culverts under Norton Promenade**
3 x 1050mm culverts are required to be constructed under existing Norton Promenade.
Responsibility for this task rests with **Satterley Property Group**.

(8) **Construction of new culverts under future Parade Road**
2 x 1050mm culverts are required to be constructed under the future Parade Road at the intersection with Bussell Highway.
Responsibility for this task rests with the **Morgan’s**.

(9) **Upgrading of existing bunds adjacent to 5MBDD between Bussell Highway and Harewood Road to ensure 18m³/sec can be conveyed without overtopping into adjoining areas.**
Water Corporation has advised the existing bunds may be inadequate and some upgrading is necessary. As such, further investigation is required.
Responsibility for this task rests with the **Water Corporation**.
4.3 Post Construction Management

(10) Management of land between Centenary Road and Washington Avenue

The land between these two roads is owned largely by the Department of Housing and Works as well as a several private land owners. Future planning for this area is shown on the Tuart Brook Concept Plan in Appendix E. The area shown as Regional Open Space has been advertised as part of the Greater Bunbury Region Scheme.

The City of Bunbury and the WAPC are to ensure that the ROS is not developed and is available for flood protection purposes. Future development in this area is to have a minimum building level of 5.6m AHD (500mm above the 100 yr flood level).

Responsibility for these tasks rests with the City of Bunbury and the WAPC.

(11) Management of the 5MBDD – North Arm

The land between the Five Mile Brook and Centenary Road falls within the Shire of Capel. The Shire of Capel and the Water Corporation are required to agree on the maintenance arrangement for the overflow drain to ensure that the passage of flood waters is uninhibited at all times. During construction of the drain, the respective developer’s will be responsible for maintenance of the drain that falls on their land holdings. The Shire of Capel will be responsible for ensuring that the drain is not filled by development works.

Responsibility for these tasks rests with the Shire of Capel, the Water Corporation and the respective Developers.

(12) Management of overflow mechanism at the junction of 5MBDD in Bussell Highway to ensure the 7m³/sec which can not pass through the culverts is directed northwards.

Subject to a further study by JDA, the existing culvert configuration, road levels, verge and median levels should not be altered without careful examination of the consequences.

Responsibility for this task rests with the Water Corporation, Shire of Capel, MRWA and to a lesser extent the respective Developers on which the land falls.

(13) Management of the Five Mile Brook Diversion Drain

This drain is currently under the care and control of Water Corporation and will remain with that organisation.

Responsibility for these tasks rests with the Water Corporation

(14) Management of ground levels on Lot 1 (Riding School for Disabled use)

This is necessary to ensure flows crossing Bussell Highway rejoin 5MBDD. This could occur if Lot 1 were to be earthworked.

Responsibility for these tasks rests with the Shire of Capel.
5. SUMMARY OF RESPONSIBILITIES

In order that the Five Mile Brook Diversion Drain – North Arm can be implemented, the table below outlines the responsibilities of each organisation:

<table>
<thead>
<tr>
<th>ORGANISATION NAME</th>
<th>PRE CONSTRUCTION</th>
<th>CONSTRUCTION</th>
<th>POST CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shire of Capel</td>
<td></td>
<td></td>
<td>1. Maintain the 5MBDD - North Arm from the point where water crosses Bussell Highway up to and including the proposed culvert under Centenary Road.</td>
</tr>
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<td></td>
<td>1. Approval of 5MBDD – North Arm conceptual design on advice from DoW.</td>
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<tr>
<td></td>
<td>2. Approval of 5MBDD – North Arm detailed designs.</td>
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<tr>
<td></td>
<td>3. Approval of DA applications for filling of land adjacent to the &quot;interim&quot; flow path.</td>
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<td></td>
<td>4. Placing conditions on subdivision applications in East Dalyellup to account for the overland flood route.</td>
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<td></td>
</tr>
<tr>
<td>City of Bunbury</td>
<td>1. Approval of 5MBDD – North Arm conceptual design on advice from DoW.</td>
<td>1. Maintain the culvert under Washington Avenue.</td>
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</tr>
<tr>
<td></td>
<td>2. Approval of 5MBDD – North Arm detailed designs.</td>
<td>2. Ensuring that the Regional Open Space (ROS) in the Tuart Brook area is not filled.</td>
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<td></td>
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<td>3. Ensuring that all lots in the Tuart Brook area are filled to a minimum level of RL 5.60m AHD</td>
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<tr>
<td>Department of Water</td>
<td>1. Provision of advice to the Shire of Capel in relation to conceptual designs.</td>
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<tr>
<td>Water Corporation</td>
<td>1. Investigate capacity of existing 5MBDD to convey a peak flow of 18m³/s downstream of Bussell Highway.</td>
<td>1. Upgrade and fund new levee banks on the existing 5MBDD where required.</td>
<td>1. Maintain the existing 5MBDD.</td>
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<tr>
<td></td>
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<td></td>
<td>2. Maintain the 5MBDD - North Arm from the point where water crosses Bussell Highway up to and including the proposed culvert under Centenary Road.</td>
</tr>
<tr>
<td>ORGANISATION NAME</td>
<td>PRE CONSTRUCTION</td>
<td>CONSTRUCTION</td>
<td>POST CONSTRUCTION</td>
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<tr>
<td>East Dalyellup Land Developers</td>
<td>1. Complete modelling of 5MBDD – North Arm and finalise report. 2. Preparation of a Preliminary Drainage Design Report. 3. Ceding of 20m wide strip of land to the Shire of Capel to cater for the 5MBDD North Arm. 4. Gaining approvals from all parties prior to works commencing.</td>
<td>1. Construction and funding of 5MBDD – North arm works as outlined in Section 2 and in the Cost Sharing Table in Appendix H.</td>
<td>1. Maintain the 5MBDD - North Arm whilst development works are in progress and prior to handover to the Shire of Capel and Water Corporation.</td>
</tr>
<tr>
<td>MRWA</td>
<td></td>
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<td>1. Ensure future alterations to Bussell Highway do not adversely impact on the 5mBDD – North Arm overflow path.</td>
</tr>
<tr>
<td>WAPC</td>
<td>1. Placing conditions on subdivision applications in East Dalyellup and Tuart Brook to account for the overland flood route.</td>
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</table>
APPENDIX A - East Dalyellup Aerial Photograph
Ray,

As requested we have further modelled the flood route and corresponding water surface profile for the estimated overflow hydrograph (maximum 7 m³/s) in the 100yr ARI storm event at Bussell Highway. This is the difference between the 100 yr ARI peak flow of 25 m³/s at Bussell Highway, less the 18 m³/s capacity of the Five Mile Brook Diversion Drain (FMBDD).

This advice supercedes previous advice on 28/11/06 (J3773I).

1. Background

Washington Avenue forms the boundary between City of Bunbury and Shire of Capel. At the request of the City of Bunbury a FMB flood study downstream of Washington Avenue through Bunbury to the ocean outlet was completed in 1996 (WAWA, 1996), together with associated steady state flood plain mapping (WAWA, 1996). This study found that the critical storm duration (resulting in highest flood levels) was 24 hours. This study assumed no overflow from FMBDD into the FMB course downstream of Bussell Highway. A 100 year ARI peak flow of 2 m³/s was estimated just downstream of Washington Avenue, with steady state water surface elevation of 4.99 mAHD. No modelling further upstream was performed. The proportional flow at Centenary Avenue has been estimated as 1.1 m³/s (JDA, 2006).

A study of the capacity of FMBDD was completed in 2003 (WRC, 2003) which concluded that it could convey 18 m³/s before overtopping of Bussell Highway. The 100 year ARI flow was estimated as 25 m³/s, so that a maximum of 7 m³/s would overflow, in a northerly direction in the vicinity of Bussell Highway. The exact flood route of this overflow was not analysed.

Hydraulic modelling of the 7 m³/s overflow was previously performed by JDA using the HEC-RAS backwater model. The HEC-RAS model estimates water surface elevation for non-uniform, steady flow conditions; there is no attenuation of the peak flow in the downstream direction, so the computed water surface is conservatively high.

It is more realistic to allow for the unsteady nature of the real flow situation.

This report details the hydraulic modelling of the estimated FMBDD overflow hydrograph using the XP-STORM model to estimate the water surface elevation and peak flow attenuation through storage in the proposed flow path north of the FMBDD along Bussell Highway to Washington Avenue, including the Regional open space (ROS) between Centenary Avenue and Washington Avenue.

The 100 yr ARI flood event of 7 m³/s has by definition a 1% chance of occurring in each year. In most years FMB itself only flows at a low flow rate, less than culvert capacity under Bussell Highway and for the majority of the time the Brook does not flow at all.

There has been no evidence at all that FMB has flowed at a rate above the Bussell Highway culvert capacity since the Diversion Drain was completed in the 1960s. The overflow modelled in this report probably only occurs at all about once in 50 yrs and at 7 m³/s as stated above once in 100 yrs.
It follows that in most years there will be no additional water flowing into the ROS between Washington Avenue and Centenary Avenue.

The Department of Water advised that based on previous analysis (WAWA 1996) it is acceptable for the 100 yr ARI flow north at Washington Avenue to be 2 m³/s with a water level in the ROS of 5.10 m AHD. The analysis and solution developed in this report is consistent with these two criteria.

2. XP-STORM Modelling

Cross sections of Bussell Highway road reserve and adjacent land on both sides between FMBD and Washington Avenue have been surveyed to provide input to the model. To account for ongoing development of Dalyellup East (between Dalyellup Beach Estate and Bussell Highway) both a “Permanent” and an “Interim” flood path have been investigated.

Modelling extends further downstream through Regional Open Space (ROS) between Centenary Avenue and Washington Avenue which was modelled as a storage basin, rather than as a set of cross sections.

A peak 7 m³/s over flow hydrograph from FMBD plus additional 2 m³/s 100 yr peak flow from catchment between FMBD and Washington Avenue on eastern side of Bussell Highway were modelled. The additional flows comprise the allowable 100 year ARI post-development flow from Dalyellup East of 1.1 m³/s, calculated as part of the 2 m³/s total flow at Washington Avenue (JDA, 2006), as referred to above. An allowance was also made of 0.9 m³/s from Tuart Grove development between Washington Avenue and Centenary Avenue.

The downstream conditions of the XP-STORM model is a time varying water level north of Washington Avenue. We have assumed that the water level is 3.07m AHD (culvert invert) at start of storm, rising linearly to 4.99 m AHD between 0 and 20 hours, constant till 40 hours and then falling linearly to 3.07 m AHD at 80 hours. WAWA (1996) steady state model shows 4.99 m AHD water level downstream of Washington Ave for the 100 yr ARI event.

If a different water level is assumed downstream, the outflow hydrograph and ROS water level will be different. For example with constant 4.99 m AHD water level, the ROS water level be higher and the outflow reduced. Alternatively, with lower water level downstream of Washington Avenue, the ROS water level be lower and peak flow will be higher. This applies to both permanent and interim and flow paths described below.

A Manning’s n coefficient for roughness of 0.035 was used for both permanent and interim flow paths, and it is conservatively assumed that there would be no reduction of flow volume by infiltration into the proposed flow channel and the ROS.

3. Proposed Permanent flood path

The permanent solution involves a proposed top wetted width of approximately 20 m together with new culvert crossings as follows:

- At Norton Promenade (where filling of the existing unfilled land will occur for urban development), three pipe culverts of 1050mm diameter and 240 m in length, as shown in Figure 1 to replace existing single 500 mm pipe culvert,
- At future Parade Road, three pipe culverts of 1050mm diameter and 50m in length,
- At Centenary Ave, two culverts of 1050mm diameter to replace existing three 500 mm pipe culverts.
- At Washington Avenue culvert reduced from 1500 mm existing to 1050mm diameter, to provide greater storage in the ROS.

The proposed flow paths and cross section locations are shown in Figure 1.

Figure 2 shows the various flow hydrographs superimposed namely:

- 1 FMBD overflow at XS-12
- 2 FMBD overflow at XS-2
- 3 Dalyellup East outflow
- 4 Tuart Brook outflow
5 Sum of 2, 3, 4; total inflow to ROS
6 ROS outflow at Washington Ave Culvert

Under the time varying water level assumption the ROS outflow hydrograph is shown in Figure 2.

The hydrograph peak is attenuated from 7 m³/s to 4.0 m³/s between XS-12 (1) and XS-2 (2). The total inflow to ROS (5) peak at 4.8 m³/s. This is attenuated to a maximum of 1.90m³/s (6) with maximum ROS water level of 5.05m AHD, consistent with WAWA (1996).

Figure 3 shows the long section with invert level and computed water surface profile.

The lateral extent of inundation between XS-12 and XS-1 is evident on the individual cross section plots presented in Appendix A1.

Associated hydrographs at each cross section are presented in Appendix A2.

Table 1 presents detailed results including Bussell Highway minimum elevation at each section and corresponding free board, which has a minimum of 0.04m at cross section 9. Note that both cross sections 11 and 12 have negative freeboard, associated with water crossing the Highway.

The Permanent flood path is considered acceptable on this basis.

4. Interim flood path

Prior to establishment of the permanent flow path, it will be necessary to ensure that an interim flood path is available at all times.

XP-STORM Modelling has been performed, assuming that all land has been filled to developed levels, except for an approximately 20 m wide strip between FMDD and Centenary Avenue within Dalrymple Beach and Ironbridge land.

Figure 4 shows the proposed flow path and cross section locations (XS-1 to XS-12), assuming existing culvert sizes and inverts at Centenary Avenue and Norton Promenade, and with Washington Avenue culvert reduced from 1500 mm existing to 1050 mm diameter to provide greater flood storage in the ROS (as for permanent flow path).

Figure 5 shows the various flow hydrographs superimposed namely:
7 FMDD overflow at XS-12
8 FMDD overflow at XS-2
9 Dalrymple East outflow
10 Tuart Brook outflow
11 Sum of 8, 9, 10; total inflow to ROS
12 ROS outflow at Washington Ave Culvert

Under the time varying water level assumption the ROS outflow hydrograph is shown in Figure 5.

The hydrograph peak is attenuated from 7 m³/s to 4.0 m³/s between XS-12 (1) and XS-2 (2). The total inflow to ROS (5) peak at 4.9 m³/s. This is attenuated to maximum of 1.99m³/s (6) with maximum ROS water level of 5.05m AHD, consistent with WAWA (1996).

The long section plot (Figure 6) shows invert levels, and water surface profile at each section and through the ROS.

The lateral extent of inundation between XS-12 and XS-1s evident on the individual cross section plots presented in Appendix B1.

Associated hydrographs at each cross section are presented in Appendix B2.

Table 2 presents detailed results including Bussell Highway minimum elevation at each section and corresponding free board, which has a minimum of 0.15 m at cross section 6. Note that both cross sections 11 and 12 have negative freeboard, associated with water crossing the Highway.

At Norton Promenade the water level is 7.35 m AHD, compared with 7.15 m AHD road level that is 0.20 m inundation depth.
Land can be developed either side of the interim flood path with the existing Norton Promenade and Centenary Avenue culverts. Washington Avenue culvert will require replacement with smaller size to reduce flow rate. The reduced culvert is part of the permanent flood path also.

The interim flood path is considered acceptable on this basis.

5. Conclusions

Two solutions (Permanent and Interim) have been progressively developed by refining XP-STORM models, both of which provide a flood path for the 100 year ARI excess flow of 7 m³/s within the limits of 2m³/s at Washington Avenue and 5.10 m AHD ROS water level, consistent with WAWA (1996).

Please contact Jim Davies or Ashraf Saadat with any queries.

Regards,

JDA CONSULTANT HYDROLOGISTS

References


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### Table 1

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<tr>
<th>Link Name</th>
<th>Max Flow (m³/s)</th>
<th>Maximum Water Elevation (US)</th>
<th>Minimum Elevation BH</th>
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<th>Max Velocity (m/s)</th>
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**Notes**

1. ROS: Regional Open Space
2. See Figure 1 for location

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Dalyellup Beach Estate Pty Ltd

Five Mile Brook XP-Storm Modelling

Table 1: Permanent Flow Path Excess of 7 m³/s upstream of section 12
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<tr>
<th>Link Name</th>
<th>Max Flow (m³/s)</th>
<th>Maximum Flow (m AHD)</th>
<th>Minimum Flow (m AHD)</th>
<th>Free Board (m)</th>
<th>Max Velocity (m/s)</th>
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**Notes:**
1. ROS: Regional Open Space
2. See Figure A for locations; Figure B for long section

Data Source: JDA Consulting Hydrologists

Job No. J3773
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Five Mile Brook XP-Storm Modelling

Table 2: Interim Flow Path Excess of 7 m/s upstream of section 12
21-Dec-2006 C:\Jobs-ASU3773\Xp Modelling\Permanent Run4.plt

Note
1. HGL is for 100yr flow excess from PM800 of 7 m3/s (upstream of x-section 12)
2. See Table 1 for details
3. XS 11, 12 are the same as invert inflow path (See Figure 4), all other section (XS 0 to XS 10) changed

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Hydraulics

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Five Mile Brook XP-Storm Modelling
Figure 3: Permanent Flow Path Long Section
Notes:
1. HGL is for 100yr flow excess from FMBDD of 7 m3/s (upstream of x-section 12)
2. See Table 2 for details
Note: All sections looking downstream
APPENDIX C - Proposed Route of Permanent 5MBDD Overland Flow Path – North Arm
APPENDIX D - Proposed Route of Interim 5MBDD Overland Flow Path – North Arm
APPENDIX E - Tuart Brook Concept Plan
OPTION FOUR

- No Washington Avenue Deviation
- 4ha given up East of Parade Road
- No Primary School Site
APPENDIX F - Concept Landscape Plan
**Typical Vegetation Buffer Corridor** (Approx. 40m length)

- Tree planting to be spaced at no less than 10m centres.
- Tree planting to have clear trunk from branches to 2m.
- Proposed groundcover planting to buffer. Planting to be maximum 150mm in height.

**Typical Vegetation Buffer Corridor Section**

- Horizontal scale 1:1
- Exaggerated vertical scale 1:3

**Extent of Works Plan**

- NTS

**TubeStock Planting**

- Scale 1:50

**45lt Tree Planting**

- Scale 1:50

**Species List**

- **Tree Planting**: Proposed Species
  - *Acacia fuscocarpa* (Red Pepperwood)
  - *Melaleuca sericea* (Swamp Paperbark)
- **Batter Planting**
  - Groundcovers: *Grevillea robusta* (Spider Flower)
    - *Grevillea hirsutula* (Spider Nest Grevillea)
    - *Grevillea obvallata* (Ginn Ginn Ginn)
- **Base of Buffer Planting**
  - *Heterophyllum complanatum* (Native Wattle)
  - *Helichrysum hypericoides* (Common Buttercup)
  - *Eucalyptus nitida* (Thick Leaved Fan Flower)
FIVE MILE BROOK DIVERSION DRAIN - NORTH ARM - ESTIMATED COSTS 4 JAN 2007

Development Areas

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<th>SPG</th>
<th>107.6 ha</th>
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<td>Morgan</td>
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<td>Small Lots</td>
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<td>Total</td>
<td>212.8 ha</td>
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Section 1: Riding for Disabled Frontage to Russel Hwy (Length = 110m)

To be funded by: MORGAN

- Acquire RDA land: $0  No Allowance
- Excavation: 814 m³ @ $15 per m³ = $12,210
- Landscaping: 0.22 ha @ $40,000 per hectare = $8,880
- Protection of Riding for Disabled land with bunding along southern boundary: $0  No Allowance
- Culverts under Parade Road (3 x 1050): 25 m @ $2,600 per m = $55,000
- Headwalls Parade Road: 2 @ $30,000 each = $60,000
- Fees on Construction Costs: 8% of $146,010 = $11,581

Total this section = $157,691

Section 2: Morgan Frontage to Russel Hwy (Length = 280m)

To be funded by: MORGAN

- Cede Land: 0.56 ha = $0  No Allowance
- Excavation: 2240 m³ @ $15 per m³ = $33,600
- Landscaping: 0.56 ha @ $40,000 per hectare = $22,400
- Fees on Construction Costs: 8% of $56,000 = $4,480

Total this section = $60,480

Section 3: Satterley Property Group Frontage to Russel Hwy (Length = 1620m)

To be funded by: SATTERLEY PROPERTY GROUP

- Cede Land: 2.76 ha = $0  No Allowance
- Excavation: 13800 m³ @ $15 per m³ = $207,000
- Landscaping: 2.76 ha @ $40,000 per hectare = $110,400
- Culverts under Norton Promenade (3 x 1550) inc traffic mgmt and reinstatement: 45 m @ $2,589 per m = $121,005
- Headwalls Norton Promenade: 2 @ $30,000 each = $60,000
- Fees on Construction Costs: 8% of $498,405 = $39,872

Total this section = $538,277

Section 4: Satterley Property Group/Small Lot Owners Common Boundary (Length = 80m)

To be funded by: SATTERLEY PROPERTY GROUP

- Cede Land: 0.16 ha = $0  No Allowance
- Excavation: 640 m³ @ $15 per m³ = $9,600
- Landscaping: 0.16 ha @ $40,000 per hectare = $7,200
- Fees on Construction Costs: 8% of $16,800 = $1,344

Total this section = $18,144
### Section 5: From Setterley Northern Boundary to Centenary Avenue alongside boundary of Small Lots (Length = 410m)

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<th>Unit</th>
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