

9. Hydrology and hydraulics

9.1 Introduction

Hydrology is the study of the movement, distribution, quantity and quality of water, specifically in relation to the natural environment. Hydraulics focuses on any changes to this environment, for example, through the built form, such as the South East Busway extension from Rochedale to Springwood in this case. Hydraulics is an engineering discipline related to the design of bridges, dams, channels, canals and culverts, among others.

Hydrology and hydraulics together therefore address the necessary measures required to 'move' water (e.g. due to rain and flooding) through the use of appropriate civil infrastructure.

9.2 Methodology

The methodology and the level of detail adopted for this investigation is at a desktop level, and is considered appropriate for corridor preservation. Rational Method hydrology has been undertaken to provide estimates of peak run-off flow rates in critical areas of interest — that is, the four major drainage crossings of the Pacific Motorway corridor.

For the culverts that will be affected by the busway extension, conveyance capacities and estimates of current flooding levels have been determined by analysis of inlet/outlet control conditions. Tailwater levels of culverts have been estimated by engineering judgement only.

The effects of extending the culverts and the determination of possible mitigation measures have also been undertaken by assessing frictional and structure losses for the relevant crossings.

Flooding levels identified within this section should be regarded as approximate only and not be used for any other purpose other than comparative purposes for the impacts of the proposed works.

Information on existing drainage infrastructure has been obtained from several sources as follows:

- Logan City Council geographic information system data
- engineering survey by Connell Wagner (January 2007)
- survey information from South East Transit Project Section 5 (detailed design by Pak-Poy & Kneebone) — this was used to verify data regarding existing drainage infrastructure only.

Further verification of the completeness and correctness of the data set used is recommended during further planning and design works.

9.2.1 Previous investigations

Pacific Motorway Transit Project — Section A Hydraulics Report

A hydraulic investigation and report for Section A of Pacific Motorway Transit Project was carried out by the Department of Main Roads in February 2007. This investigation is relevant in terms of providing regional hydraulic information.

South East Busway Extension Stage 2 — Rochedale to Springwood Pre-Feasibility Study

The purpose of this pre-feasibility study was to establish and assess possible alignments for extending the South East Busway from Underwood Road, Rochedale, to near Fitzgerald Avenue, Springwood. This study identified the need to retain the detention basins adjacent to the existing Springwood bus station and the need to consider the location of existing drainage infrastructure with the design of any elevated sections of roadway.

Springwood bus station — Investigations 1 & 2

Hydraulic analysis of the (then) proposed Springwood bus station was undertaken by Sinclair Knight Merz in February, 2002. This study confirmed the hydraulic elements required (drainage conduits and basin characteristics) so that the Springwood bus station could be constructed whilst maintaining the pre-existing detention basin's attenuation role within the regional hydrological regime.

The analysis indicated the following fundamental design characteristics of the basin:

- 100 year average recurrence interval peak water surface level of 20.18 metres Australian Height Datum
- 100 year average recurrence interval storage volume of 6,400 cubic metres
- critical 100 year average recurrence interval storm duration of 60 minutes.

9.2.2 Additional investigations

This hydrological and hydraulic review has been undertaken to describe the regional hydraulic features in the area that will be affected by the South East Busway extension from Rochedale to Springwood. It is intended to identify/provide the following:

- existing drainage flow paths and drainage networks within the extension corridor
- areas adjacent to the extension corridor currently affected by overland flow and ponding during rainfall events
- applicable drainage standards (from the Department of Transport and Main Roads and Logan City Council)
- potential drainage or flooding impacts that may be caused by the proposal
- mitigation measures that could be undertaken to compensate for the potential impacts due to the extension
- preliminary sizing of mitigation measures and/or necessary alterations to existing drainage infrastructure.

9.3 Preliminary analysis

9.3.1 Existing situation

The study area for the South East Busway extension from Rochedale to Springwood is a 2.3-kilometre-long section along the eastern side of the Pacific Motorway. Within this section there are four locations where major stormwater flows cross the motorway corridor. The terrain drains towards the corridor from the east, discharging to the west of the corridor to a series of open channels and culverts in the upper reaches of Slacks Creek, which flows to the Logan River.

At the northernmost two existing drainage crossing locations, the busway extension will involve filling within existing areas upstream (of the transport corridor) that are subject to inundation. This will necessitate the extension of the existing culverts at these locations. There are existing floodplain storage volumes associated at these two areas which will be significantly reduced by the busway extension.

There is an existing open drainage channel that runs parallel to the existing motorway (approximately between Roseland Avenue and Karoonda Crescent) that will be filled in order to construct the extension. This causes loss of flood storage and conveyance capacity which will require mitigation to ensure a 'non-worsening' condition prevails after the implementation of the busway extension.

The two southernmost major drainage crossings are not adversely affected as the inlets to these are not within areas affected by the busway extension.

Regional flooding

Logan City Council's town planning overlays indicate that the study corridor is flood free. There are several waterways downstream of the study corridor that are subject to flooding. These waterways are dedicated drainage paths and the flooding of private property during the currently recognised major flood event is not foreseen.

Applicable drainage standards

Local Authority

Logan City Council adopts the Queensland Urban Drainage Manual (Department of Natural Resources and Water 2007) as its primary drainage standard and nominated the following design average recurrence intervals):

- major event — 50 years
- minor event: residential areas — 2 years
- minor event: commercial/industrial areas — 10 years
- minor event: collector roads (or higher classification) — 10 years.

Department of Transport and Main Roads

The Road Drainage Design Manual (Department of Main Roads 2002) nominates 50-year average recurrence interval capacity for crossings of major roads. There is also a requirement that no afflux (increase in water level due to alterations in the drainage path) occurs as a result of proposed works. The check for no afflux conditions is usually undertaken for events up to a 100-year average recurrence interval.

Longitudinal drainage infrastructure along the South East Busway extension to Springwood will need to provide sufficient capacity to ensure flow widths do not encroach into trafficable lanes in the 10-year average recurrence interval event and that the major (50-year average recurrence interval) event is contained within the roadway with an acceptable freeboard to adjacent buildings.

9.3.2 Managing issues and opportunities

Alterations to existing drainage infrastructure

The extension will necessitate (at a minimum) the following:

- relocation of the existing underground system within Rochedale Road and in the vicinity of the Springwood Road underpass to the Pacific Motorway
- reshaping of detention basins in the vicinity of the Springwood bus station
- extension or modifications to existing drainage connection within detention basins:
 - 2/1,200 mm reinforced concrete pipe
 - 3,300 mm x 2,100 mm reinforced concrete box culvert
- extension of the 1,500 mm diameter culvert at chainage 2570 m for a length of approximately 16 metres to the upstream end
- extension of the 3/1,500 mm-diameter culvert at chainage 3100 m for a length of approximately 37 metres on the upstream end
- lengthening and relocation of existing culvert outlets adjacent to the southbound onramp to the Pacific Motorway near the intersection of Fitzgerald Avenue and Rochedale Road.

Impacts

The South East Busway extension from Rochedale to Springwood will cause an increase in the overall catchment's impervious fraction, and hence increase run-off. The actual increase in the impervious fraction of the entire catchment(s) under consideration is, however, very minor — as will be the flow increase caused. Consideration into mitigation of this increase has not been considered at this time and may not be warranted, however it should be confirmed prior to detailed design.

The Pacific Motorway cross drainage culvert extensions will result in a higher invert level on the upstream end of the culverts and this has the potential to increase flooding levels as does the loss of detention storage volume. The increase in the elevation of culvert headwaters may cause increased tailwater levels to upstream drainage systems which could reduce their capacity.

The following areas will be impacted upon by the South East Busway extension from Rochedale to Springwood:

- loss of flood storage at existing sag to the rear of the properties fronting Roseland Avenue and Anna Marie Street (approximate chainage 2570 m)
- loss of storage at existing sag to the rear of properties fronting Karoonda Crescent (approximate chainage 3100 m)
- reduction in width available for overland flow paths approaching the two sag points referred to above.

It is also necessary to realign Rochedale Road to provide the width required for the busway extension between approximate chainage 3600 m and the Vanessa Boulevard intersection immediately south of the Springwood bus station. This will necessitate the relocation of the existing drainage system in the area affected.

Springwood bus station detention basin

The alterations to the Springwood bus station necessitate road works within the storage volume of an existing detention basin system. The basin system consists of three separate storage zones interconnected by large drainage conduits which act to equalise the water surface level between the storages which are separated by embankments.

Terrain modelling done to date for the Concept Design Study indicates that the alterations to the bus station and the associated road works can be undertaken without reducing the Nett storage volume (i.e. a storage volume of 6,400 cubic metres can be maintained at an elevation of 20.18 metres AHD). Therefore the potential impact on the existing detention basin can be managed with an appropriate design approach.

Existing drainage system in Rochedale Road

The relocation of drainage infrastructure within Rochedale Road can be designed and constructed to provide a system equivalent to the existing case without any foreseeable negative impacts on local flooding. It has been assumed that providing a relocated drainage system using pipe sizes similar to those existing will be acceptable to Logan City Council for the following reasons:

- the existing system should satisfy current drainage standards — however, should it not be up to standard the cost of the upgrading works should not be borne by the busway extension
- the realignment of Rochedale Road will result in similar pavement levels and grades to the existing.

Estimated rises in culvert headwater levels

For the culverts at chainage 2570 m (1,500 mm diameter) and chainage 3100 m (3/1,500 mm diameter) the culvert capacity and headwater elevations have been calculated for the current (base case) and with their lengthening as required by the busway extension. It is assumed that the culverts would be extended at their existing slope without the use of a junction chamber. The estimated capacity of each of the culverts is in the order of 50 to 100 years which indicates that they currently provide an acceptable level of immunity. A summary of the two culverts are contained in Table 9-1.

Table 9-1: Summary of affected culverts

Chainage	Size (diameter)	Estimated capacity (m ³ /s)	Existing headwater level at capacity (m AHD)	Extension length (m)	Headwater level upon culvert extension (m AHD)	Rise in flood elevation (m) #
2570 m	1,500 mm	7.6	40.45	16	40.7	0.25
3100 m	3/1,500 mm	19.2	30.46	37	31.26	0.80

without mitigation measures

It can be seen that the estimated flood levels would rise based on the calculated culvert headwater depths. The 3/1,500 mm diameter culvert at chainage 3100 m is affected to a higher degree than the single 1,500 mm diameter culvert at chainage 2570 m and more significant mitigation measures will be required here.

Existing outlets near Fitzgerald Avenue and Rochedale Road

The relocation of the existing drainage outlets by lengthening the drain lines near the southbound motorway onramp can also be carried out without adverse effects to the existing capacity of these drainage lines. The pipes appear to have a free outfall and the short extensions to the downstream side of the existing outlets should not adversely affect their hydraulic performance.

Culvert extensions

The widening of the transport corridor results in the acquisition of some of the flood-affected land.

1,500 mm diameter culvert at chainage 2570 m

This culvert can be improved by providing a bell-mouthed inlet. This has the potential to reduce inlet losses sufficiently to retain the headwater level required for the culvert's capacity for the current situation.

3/1,500 mm diameter culvert at chainage 3100 m

Due to this culvert's greater extension length and steeper culvert slope, a similar inlet improvement (bell mouth) alone does not satisfactorily mitigate the impact. Two other options have been considered which meet the culvert headwater level requirement as follows:

- option 1 — extend with larger culvert barrels
 - extend with 3/1,800 mm diameter pipes
 - construct a benched junction chamber for the connection and a bell-mouthed inlet to the 3/1,800 mm diameter pipes to minimise head losses
- option 2 — provide a bridge between approximate chainages 3080 m to 3110 m
 - not extending the culvert and providing a localised bridge will allow overland flows to pass unrestricted beneath the busway extension to arrive at the existing culvert inlet.

Option 1 is expected to have a lesser construction cost and has been assumed for estimating purposes.

South East Busway extension from Rochedale to Springwood — corridor drainage infrastructure

The extension will require a surface drainage system to satisfy Department of Transport and Main Roads requirements, as per the Road Design Drainage Manual. For the purpose of the Concept Design Study, the preliminary sizing of longitudinal drainage lines, the spacing and location of inlet pits have been estimated by the following:

- using Rational Method calculations to calculate Q_{10} piped flows for the major sub-catchments
- calculation of piped capacity by estimated hydraulic slopes within the system during the design event
- assessment of likely flow widths at various locations along the extension
- engineering judgement.

South East Busway drainage outfalls

The longitudinal drainage system is envisaged to require outlets at the following locations:

1. inlet to 1,500 mm diameter culvert (crossing Pacific Motorway) at chainage 2570 m
2. inlet to 3/1,500 mm diameter culvert (crossing Pacific Motorway) at chainage 3100 m
3. existing drainage system at the Springwood Road underpass of the Pacific Motorway
4. existing 2/1,450 mm diameter culvert (crossing Pacific Motorway) at chainage 4400 m

Upon this initial assessment it appears that the outfalls at numbers 1 and 2 above are not in constrained areas and can be provided with minimal impact.

Outfall number 3 will need to be directed to the existing system that drains the Springwood Road underpass. Some localised augmentation to this system will be required to compensate for the additional inflows from the busway extension.

Outfall number 4 will need to be directed to an existing inlet structure and at this stage it is not envisaged that this will be a significant impact.

9.4 Future investigations

Further hydrological and hydraulic analysis will be required to more accurately determine flood levels, the impacts of the proposed expansion of the transport corridor, and requirements of mitigation measures. These should include a more detailed hydrologic analysis of catchment run-off and routing of flows through storages within the study area. Hydraulic modelling of the cross-drainage structures and tailwater levels within the regional system for the current (base case) situation and for the proposed 'post works' case should be undertaken to be able to demonstrate a non-worsening (or 'no afflux') upon the proposed busway extension. Current detention storage areas and changes to them caused by the busway should be included in the analyses.

The detention basin at the Springwood bus station will require further terrain modelling in the design phase to ensure storage volumes are retained in the final design. Further amendments should be made to the existing Mike 11 model of the basin to ensure that any alterations made to the storage areas and connecting pipes do not alter the basin's hydraulic performance during events of up to 100 year average recurrence interval.

9.5 References

Connell Wagner 2008, 'Pre-Feasibility Study, South East Busway Extension Stage 2 – Rochedale to Springwood', report for Queensland Department of Main Roads/TransLink, Brisbane.

Connell Wagner 2007, 'Pacific Motorway Transit Project Section A Hydraulics Report', report for Queensland Department of Main Roads, Brisbane.

Logan City Council 2006, 'Planning Scheme Policy number 5 (Design and Construction of Work)'.

Logan City Council 2006, 'Planning Scheme Overlay Map 2 (Flood Plain Management)'.

Logan City Council 2006, 'Planning Scheme Overlay Map 6 (Wetland and Waterway Areas)'.

Queensland Department of Main Roads 2002, *Road Design Drainage Manual*, Queensland Department of Main Roads.

Queensland Department of Natural Resources and Water 2008, *Queensland Urban Drainage Manual*, Queensland Department of Natural Resources and Water.