Manual

Road Drainage
Chapter 8: Open Channel Design

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8 Open channel design

8.1 Introduction

Section 2.1.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section, subject to the following amendments.

Addition(s)

1. Open channels have the advantages of continuous collection of surface runoff, and where the system surcharges, general shallow flow is the most likely outcome rather than more concentrated flooding at upstream inlets of the closed drainage system.

This manual focuses on the analysis and design of channels, smaller streams and creeks. Assessment of larger streams, creeks, rivers and floodplains is complex and should be referred to the Hydrology and Hydraulics and Flooding Section, Engineering and Technology Branch or a suitably prequalified consultant.

The Hydrologic and Hydraulic Modelling Technical Guideline (TMR, 2019) should be referred to when dealing with cross-drainage and flooding issues.

8.1.1 Open channels

Sections 2.1.2 to 2.1.4 of the Austroads Guide to Road Design – Part 5B are accepted for this section subject to the following amendments.

Addition(s)

1. Open channels may be constructed to specified criteria:
   - as part of the road drainage system where space within the road reserve is sufficient to provide for open channels
   - as diversion channels, especially where the road is being constructed generally along the line of a watercourse and severs one or more meanders in the stream. Care must be exercised as shortening of the stream will increase the gradient and hence velocity, which may induce scouring and also prevent the upstream passage of fish
   - from the outlets of culverts or drainage systems.

8.2 General considerations

Section 2.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.3 Local authority requirements

The requirements of local government should be sought for any significant open channel design, particularly in developed areas or where the channel forms part of a major drainage system as defined in Chapter 2.

There is a need to check the effects of flows larger than the design flood and to understand the likely impacts. Where flooding of property is a possibility, the effects of an extreme event larger than the design event should be analysed even if there is no local government requirement.

Other local government requirements may include the provision of access/maintenance berms, barrier fencing and appropriate warning signs to prevent access to the channel and a low flow channel to take a minimum flow.
Water sensitive urban design (WSUD) is an important aspect of pollution control and the design of open channels should consider these requirements. Chapter 2 outlines the principles of WSUD while Chapter 7 provides more information and detail.

### 8.4 Fundamentals of open channel flow

#### 8.4.1 Stream dynamics

Section 2.3.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section. However, it should be noted that the Manning's roughness coefficient is not dimensionless, when using the (SI) system, \( n = \text{Manning's Roughness coefficient} \ (s/m^{1/3}) \).

#### 8.4.2 Assumptions for analysis

Section 2.3.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

#### 8.4.3 Fundamental equations

Section 2.3.3 of the Austroads Guide to Road Design – Part 5B is accepted for this section subject to the following amendments.

**Addition(s)**

1. For natural channels, a comparison may be made with the photographs in Figure 8.4.3. Appendix C of the Natural Channel Design Guidelines (BCC, 2003) shows photos and tables of Queensland Streams and their recommended Manning's Coefficients.

*Figure 8.4.3 – Natural streams in Queensland*

\[
n = 0.03
\]
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- $n = 0.04–0.045$
- $n = 0.05–0.06$
- $n = 0.07$
n = 0.08

Notes:
1. Increase in ‘n’ value with an increase in grass, weeds, shrubs and trees.
2. In general, growth of trees in photographs tends to look denser than when seen on a site inspection.
3. Except for n = 0.03, roughness is for bank full flood heights and/or floods in upper branches of the trees.
4. Use photographs with caution. Use in conjunction with Table 2.2 of the Austroads Guide to Road Design – Part 5B

8.4.4 Application of fundamental equations

Section 2.3.4 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.4.5 Energy principles

Section 2.3.5 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.4.6 Hydraulic jump

Section 2.3.6 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.4.7 Hydraulic drop

Section 2.3.7 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.5 Erosive velocities in natural streams

Section 2.4 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.6 Backwater

Section 3.7.1 of the Austroads Guide to Road Design – Part 5 is accepted for this section.

8.6.1 Tidal waters

Backwater as a result of tidal flow can affect stream flow and, in turn, drainage infrastructure design.

When determining backwater effects on tailwater levels for streams discharging into tidal waters, three factors may influence the final design level:

- tide levels
- storm surges
- climate change.
8.6.1.1 Sea and tide levels

Section 3.7.2 of the Austroads Guide to Road Design – Part 5 is accepted for this section, with the following addition:

1. In the past Highest Astronomical Tide (HAT) and Mean High Water Spring (MHWS) levels could be sourced from the Tidal Planes tables published by Maritime Safety Queensland (MSQ). However, information from this source can no longer be relied on, as there has been no adjustment to those since 2010. Therefore, tidal levels need to be obtained and validated from alternative sources such as the Department of Environment and Science.

8.6.1.2 Storm surge

A storm surge is the rise (or fall) of open coast water levels relative to the normal water level and is due to the action of wind stress and atmospheric pressure on the water surface.

Storm surges occur as part of major storms such as cyclones where there are low atmospheric pressures and the wind blows over reaches of the ocean.

Many local authorities in Queensland have prepared reports and maps showing storm tide risk in coastal areas. These reports can be found on relevant council websites.

In the absence of specific storm tide information, the Department of Environment and Heritage Protection (DEHP, 2013) has recommended a default level. This level is 1.5 m above HAT in southeast Queensland and 2.0 m above HAT in the rest of Queensland. There is no probability associated with this recommendation, so it is assumed that this applies to 1% AEP + climate change events out to the 2100 planning horizon. These values are a conservative estimate including an allowance for future sea level rise, so adoption of this level will usually result in a higher flood level than would be found from a more specific analysis. A less conservative approach is to adopt HAT as an approximation of a coincident storm surge in addition to a MHWS tide level. Coincident Probability Assessments

Australian Rainfall and Runoff 2019 (ARR19) outlines methods to assess the interaction of coastal processes and severe weather events (ARR Book 6 Chapter 5, Ball, et al., 2019). The additional complexity of joint probability modelling means that the methods described in ARR19 should only be implemented by users with sufficient understanding of the theoretical basis of each method. However, ARR19 suggests that where there is little difference between complete dependence and independence, the analysis should assume complete dependence, which will result in a degree of conservatism.

8.6.1.3 Design Guidance

Consideration of storm surge and storm tide is important in design of Department of Transport and Main Roads infrastructure and must be considered appropriately to ensure that the design considers the flood risk correctly. There is a possibility that the design may be overly conservative if flooding, high tides and storm surge are all assumed to be coincident. In practice, there is a slightly higher probability that they are associated, but the assumption of full dependence is generally too conservative.

The recommended design procedure for the hydraulic assessment of Department of Transport and Main Roads drainage infrastructure located close to the coast, where tidal influences may be an issue is as follows:

1. Obtain MHWS, HAT and storm tide levels relevant to the infrastructure.
2. In most cases it is acceptable to simply adopt the higher levels resulting from independent storm tide and riverine flooding with HAT tailwater conditions. This approach includes some degree of dependency in the design.

3. If a more detailed analysis is required, undertake pre-screening exercise to determine if there is significant difference between:
   - full dependence: flood levels based on riverine flooding with storm tide tailwater levels
   - partial dependence: maximum flood levels resulting from either storm tide levels or riverine flood levels with HAT tailwater condition
   - full independence: maximum flood levels resulting from either storm tide levels or riverine flood levels with MHWS tailwater condition

4. If the difference is sufficiently small to accept, adopt the ‘full dependence’ or the ‘partial dependence’ case as the design condition, which will usually result in a slightly conservative design.

5. If the assumption of full or partial dependence has significant impacts on the design of the infrastructure, a joint probability analysis in accordance with Section 5.5, Book 6 of ARR19 is recommended to determine the required design levels of the infrastructure.

6. As a check, the catchment floods should also be analysed with a lower tailwater level to check for design flow velocities to determine scour potential. The lower tide level should be mean sea level or MLWS.

8.6.2 Downstream tributary

If the crossing is located on a stream which joins another watercourse (larger or smaller) downstream, other issues need to be considered.

As the two open channels have different catchment sizes, they will peak at different times. The combined flow at their junction needs to be assessed.

In this case, two situations need to be considered:
   a) major flood on tributary with limited flow in the main stream
   b) major flood on the main stream and limited flow in the tributary.

Both cases need to be analysed to provide an understanding of the potential flood conditions at the road. The risk of coincidental flooding in the two streams needs to be considered to determine the combined risk of flooding. Depending on the relative sizes of the two streams, it may not be realistic to expect floods to occur together in the two streams.

If the assumption of full or partial dependence has significant impacts on the design of the infrastructure, a joint probability analysis in accordance with Section 4, Book 4 of ARR19 is recommended to determine the required design levels of the infrastructure.

8.7 Tailwater levels

Section 2.6 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.7.1 Tailwater effects

Section 2.6.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section.
8.7.2 Design tailwater levels
Section 2.6.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.8 Open channel design
Section 2.7 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.8.1 Design methodology
Section 2.7.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section subject to the following amendments.

Addition(s)
1. Freeboard is the additional height of channel required above the height of the design flow. This allows for inaccuracies in data used in calculation and possible surcharge due to silt/debris build up and/or grass growth in the channel because of delayed maintenance of the channel.

8.8.2 Channel transitions
Section 2.7.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.8.3 Energy losses in channel bends
Section 2.7.3 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.8.4 Superelevation in channel bends
Section 2.7.4 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.9 Grassed channels
Section 2.8 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.9.1 Normal grassed channels
Section 2.8.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.9.2 Reinforced grassed channels
Section 2.8.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.10 Channels lined with hard facings

8.10.1 General
Section 2.9.1 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.10.2 Riprap and rock filled wire mattresses/gabions
Section 2.9.2 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.10.3 Concrete lined channels
Section 2.9.3 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.11 Channel drops
Section 2.10 of the Austroads Guide to Road Design – Part 5B is accepted for this section.
8.12 Baffle chutes

Section 2.11 of the Austroads Guide to Road Design – Part 5B is accepted for this section.

8.13 Worked examples

Section 2.16 of the Austroads Guide to Road Design – Part 5B is accepted for this section.