3 Strategic planning and development control

3.1 Introduction

This chapter addresses two departmental functions that are important in the pre-planning of a road corridor or link and the ongoing stewardship of a road with respect to drainage.

The first is concerned with strategic planning and the major drainage considerations required when developing strategies and plans for state-controlled roads and roads within the National Land Transport Network (Auslink). The second is concerned with the possible effects on road drainage systems, due to the development of the road and external environments (refer to Section 3.2.2).

3.2 Strategic planning

3.2.1 Introduction

Chapter 2 has described various design considerations, controls, criteria and standards that apply when planning a drainage system. This section expands on these aspects, with a focus on strategic, pre-project planning.

The design considerations for the strategic planning of drainage include:

- flood immunity
- community impacts
- safety
- environmental impacts.

This section will discuss key aspects affecting flood immunity and community impacts. These aspects need to be carefully considered and initially addressed when allowing for road drainage at the strategic level of planning. Safety and environmental considerations will not be discussed; however, it is essential that any planned or proposed changes to the road environment through the development of the road should not have an adverse effect on safety and the environment.

3.2.2 Flood immunity

In the planning of a road corridor, link or project, the flood immunity expected/required is an important consideration. However, as stated in Section 2.1.3 and detailed in this chapter, the assessment/determination of flood immunity for a road is extremely difficult.

The accepted practice is to assess/prescribe the flood immunity for individual types of drainage infrastructure, such as cross-drainage and surface drainage infrastructure, along the road. The department’s general design criterion for flood immunity for cross-drainage on state-controlled roads is to achieve a design that provides for an Annual Exceedance Probability (AEP) of 2% (= Average Recurrence Interval (ARI) 50 year). Projects on roads within Auslink usually require immunity for an AEP of 1% (ARI 100 year). Designers should refer to Section 2.5 for specific requirements.

While all road planning and design projects should aim for these objectives, there are a number of considerations that affect this objective in particular circumstances. This section discusses some of these circumstances and outlines how these additional issues can be incorporated into the process.

For the project concerned, additional considerations are needed in the assessment of flood immunity required. These include:
• Project economics – in some circumstances, provision of a required level of flood immunity may come at a very high cost, which may be difficult to justify because of the function of the road. This situation often occurs in large flat floodplains, where there is an extensive length of road across the floodplain.

• Road alignment and corridor – in some situations, the road alignment and corridor width may make a high level of flood immunity difficult to achieve and a lower level may need to be adopted. This situation usually occurs in areas with significant controls or constraints where there are environmental issues or in urban areas.

• Community impacts – these impacts may affect the flood immunity standard to be adopted, especially in flat areas. Often in these situations, there will be a significant width of flow in the natural or existing environment. If the road is to be upgraded to a higher level of flood immunity, a significant flow must be directed under the road, which will tend to concentrate the flow. In this case, afflux is difficult to manage without a significant amount of cross-drainage. A lower level of flood immunity will allow extra flow across the road and, thereby, result in a better outcome related to afflux. This benefit may be greater than the concern with the reduced flood immunity.

• Flood immunity along a road link – in this case, the flood immunity along a whole road link needs to be considered. If there is a drainage crossing on the road link where it is clear that it cannot be upgraded to a 2% AEP (≈ ARI 50 year) flood immunity, the upgrade of other crossings on the link may not be justified, because the whole link may be closed anyway whether or not the particular crossing is upgraded. This issue can be influenced by the availability of an acceptable alternate route.

In all of these cases, the required level of flood immunity would usually be technically achievable, though at a cost that cannot be justified for the benefit gained. For example, the Murray River Crossing in north Queensland, as shown in Figure 3.2.2, has been designed based on a Time of Closure (TOC) criteria, as the cost to construct the highway to normal levels of immunity was prohibitive.

The consequences of adopting a lower level of flood immunity can be analysed by consideration of the extent of traffic disruption and the economic impacts of this disruption. This can be considered in conjunction with the assessment of TOC discussed here.

While it may be acceptable to adopt a flood immunity standard for a project that does not meet the general criterion, in all cases it is essential that the justification for the decision should be clearly detailed.

**Figure 3.2.2 – Murray River Crossing of Bruce Highway**
3.2.3 Community impacts

3.2.3.1 Time of Closure

Sections 4.5.2 and 4.5.3 of the Austroads Guide to Road Design – Part 5 and 4.4.3 of the Austroads Guide to Road Design – Part 5B are accepted for this section subject to the following amendments.

Addition(s)

1. It may be the case that a road with a low level of flood immunity is closed for short periods of time (though frequently), in which case there may be limited disruption to transport and the low flood immunity may not be a serious concern.

TOC depends on the catchment response time. Small and steep catchments flow faster and the TOCs will be relatively short, while large and flat catchments will have a longer TOC. Therefore, a small steep catchment where the flood immunity of the road is low may suffer a similar amount of traffic disruption, over a long period of time, as a large flat catchment with a higher flood immunity standard. This means that additional data for selection of an appropriate flood immunity standard can be gained from consideration of TOC.

Because of this factor, TOC can be considered in conjunction with the flood immunity, possibly to adjust the design criteria for a particular crossing.

Through the analysis of TOC, the costs of traffic disruption can be analysed and decisions made on the level of flood immunity that can be justified for the investment.

This analysis is an important consideration in the road planning process but, as with the possible adoption of a lower level of flood immunity, careful justification of the TOC is needed in the analysis.

3.2.3.2 Risk of link closure

When planning the desired immunity level of a road link, an important concept that is often not understood or implemented well, is the assessment of the risk of closure. This concept or issue is particularly important where there is no realistic alternative route available.

The key part of the risk assessment that is poorly understood is the link between the design AEP for cross-drainage structures and the probability of closure of the road link. The probability of closure for an existing road link is not simply based on the minimum AEP standard of all cross-drainage structures along the road link. Equally, it is incorrect to set the acceptable level of risk of closure for the road link and then adopt this level (in the form of an AEP) for the design of each drainage crossing. This will not necessarily achieve the desired level of immunity or risk of closure.

The department usually designs individual cross-drainage structures to a standard of 2% AEP (≈ ARI 50 year). Statistically this means the probability of the road being closed at one of these crossings is 2% annually. However, due to the independence of rainfall events over time and potentially between catchments, any drainage crossing along the link could close, due to a greater than 2% AEP (≈ ARI 50 year) event, independent of all other crossings. This situation, when considered across the whole road link, could greatly increase the risk (probability) of closure of the road link.

The assessment of probability of closure for a road link requires the determination of dependency between the crossings: that is, are the crossings along a road link independent of each other or not? The level of dependency influences the level of probability and therefore risk of closure.
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This can be explained by use of an example. Assume a road link with five drainage crossings, each designed with a flood immunity of 2% AEP (≈ ARI 50 year). If all of the crossings on the road link are totally dependent, then a single rainfall event greater than 2% AEP (≈ ARI 50 year) will close all of the crossings at the same time. This gives the road link a probability of closure of 2% (1 in 50). However, if the crossings are fully independent, each crossing can be subjected to its own greater than 2% AEP (≈ ARI 50 year) rainfall event at different times to the other crossings. Therefore, the risk of closure of each crossing is independent of what occurs at the other crossings. This situation can give the road link a probability of closure of about 10% (1 in 10).

Normally, the crossings are dependent to a certain extent and the risk will be between the two cases described. In this case, a single event may affect more than one crossing at a time on some occasions, but they will be affected independently at other times.

Crossings will be fully dependent if the length of the road link is small and a single rainfall event will always affect all crossings together. The dependence decreases as the length of the road link increases and the probability of a single rainfall event affecting all catchments reduces. The dependence is low when there are many small catchments. In this case, each small catchment may be affected by a localised short duration storm event, which will only extend over a limited geographical area, and these events may occur anywhere along the road.

For example, if there is a long length of road with 50 small catchment areas, each with its own crossing designed for a 2% AEP (≈ ARI 50 year) flood event, the risk of closure of the road link is quite high in every year.

The analysis of this risk is complex and depends on an assessment of the catchment types, the expected rainfall mechanism and the distance between crossings.

Calculation of the risk of closure of the whole link needs to consider the flood immunity of each individual crossing as well as the degree of independence of the crossings.

The analysis of this combined risk is a complex statistical analysis. However, it should be considered in many projects, to ensure that there is a good understanding of the total risk of closure. For further discussion and/or advice regarding this type of analysis, contact the Director (Hydraulics and Flooding), Hydraulics and Flooding Section, Engineering and Technology Branch.

3.2.3.3 Flood impacts

While the risk of traffic disruption, as shown in Figure 3.2.3.3, is the main criterion for selection of suitable flood immunity, the impacts on the local environment and community also contribute to the selection of flood immunity.

The impacts on the community result especially from directing flow from a wide flow path over the road through a relatively narrow set of drainage structures.
In order to meet the initial required immunity level, the provision of sufficient drainage structures may not be justified by cost and therefore a lower flood immunity may seem to be an appropriate option. In this case, the additional cost of providing the extra drainage to meet the initial required immunity must be balanced against the extra inconvenience (time and cost) of more extensive road closures that would result from selecting a lower level of flood immunity.

However, this situation may be justified, especially in flat floodplains where there are extremely wide flow paths. The justification also depends on the traffic volume and the nature of the traffic using the roadway.

### 3.2.4 Acceptance of a lower standard

While the drainage design for state-controlled roads and roads within Auslink should provide for the general required level of flood immunity, there are situations where this standard is impossible to meet. In this case, and after careful consideration of the issues presented here, a lower standard of flood immunity may be adopted.

However, if this is the case, the justification of this decision must be documented.

### 3.3 Development control

#### 3.3.1 Introduction

There are two aspects of development control related to drainage that the department must consider.

First, the department could be regarded as a developer because it controls and directs the construction of road infrastructure and this development may have an impact on the surrounding environment, both natural and built. Road planning, therefore, must determine, assess and mitigate any impacts to an acceptable level.

Second, the department needs to be aware of development near roads and/or in a catchment that may impact on existing departmental drainage infrastructure. This impact could be a change in flood levels or flows or a diversion of runoff. The department is consulted on development approvals when the proposed development is within 100 m of an existing or future planned state-controlled road. This criterion provides for a number of developments, but there are occasions where the proposed development is in the catchment draining to the road crossing, but further away. Development anywhere in the catchment may have an adverse impact on the road drainage, even if it is remote from the road. In this case, the department must maintain surveillance of development and make appropriate allowances or provide advice to developers or a council. Consultation with local authorities assists in this provision.
Both of these aspects must be analysed to ensure that the department’s road infrastructure is and/or remains acceptable from the point of view of drainage considerations. To enable analysis of these aspects, the department must firstly determine or establish the hydrologic/hydraulic conditions of the site including the capacities (and immunity level) of any existing drainage infrastructure.

This is a complex area and it is difficult to provide any clear-cut criteria, but there are some general principles that should be considered in assessment of development and this section has some comments on relevant issues.

3.3.2 Departmental impacts

When the department builds a new road or rebuilds/upgrades an existing road, the drainage impacts of this road must be considered. There are three main aspects, namely afflux, the concentration of flow and flow diversions.

Permissible levels of afflux are discussed in Chapter 2 and should be referenced in all cases. Afflux is a critical consideration/criterion as it is often the controlling factor in drainage designs. New road embankments and changes to existing embankments (even by small amounts) will create or change water levels both upstream and downstream of the crossing. These impacts need to be determined and mitigated.

Generally, floodplain flow will tend to be concentrated when directed through culverts under the road. This concentration of flow provides a higher risk of scour at the culvert outlet. The design, therefore, must consider this risk and make appropriate allowances.

Roads may actually change the direction of flow in some circumstances, and this diversion could have serious adverse impacts on the environment and neighbouring property owners. The design must carefully review the possible flow redirection and generally minimise any diversions.

The impact of road drainage on flooding is usually analysed for the range of floods down to an AEP of 1% (up to ARI 100 year), the most commonly used flood criterion for floodplain management in local authorities.

However, in some circumstances, it may be appropriate to consider larger floods, even extreme events. This situation usually arises in urban areas, or where there are particularly sensitive locations. It is also only relevant where the road construction may cause obstruction to flow for larger floods, while allowing the smaller floods up to 1% AEP (ARI 100 year) to pass through the drainage structures. Occasions where this may be important is where there is a high embankment, where there may be safety or noise barriers on the road or where overpasses cause obstructions.

The road design should be reviewed in all cases, and specific analysis should be conducted in cases where this is considered necessary. A risk assessment should be carried out in each case and if necessary, modifications should be made to the design.
3.3.3 Development impacts

The most important development issue of concern for the department is urbanisation (including residential and commercial development). Urbanisation increases stormwater runoff from a catchment. However, while urbanisation may be the most significant development that may affect road drainage, there are other forms of development that may also have an impact. These include:

- levees and other farm works – these may divert flows across the floodplain and may, therefore, change the point where flow must cross the road
- dams, detention basins and other water storages may affect flood levels and discharges.

Refer to Figure 3.3.3.

Figure 3.3.3 – Detention basin in a residential subdivision

Urbanisation increases stormwater discharge by increasing the impervious area in a catchment and by improving the channel conditions. The combination of these two factors increases the volume of runoff and the peak discharge, and changes the time the peak discharge occurs, both of which may affect the existing road drainage. Furthermore, urbanisation generally provides artificial flow paths and can reduce the floodplain storage by the filling of depressions and so on. These aspects also increase the flood discharge. Any increase in discharge will most likely affect the flood immunity of the road as it would have been designed for less runoff. The impacts to departmental drainage structures (located downstream of development) can be the increased chance of overtopping the road and/or increased outlet velocities. These factors, in turn, increase the risk of scour, water quality problems and safety concerns. Also, the increased discharge will most likely increase the peak water levels at that location, increasing the level of flooding.

Urbanisation or development downstream of departmental drainage structures may change the condition of the outlet channel (in the external environment). Change or improvement in the channel will most likely change the tailwater level at the structure. If the channel can drain the stormwater away more quickly than before the changes were made, the tailwater at the structure will drop. This can change the operation of the culvert and, in turn, could mean increased outlet velocities. If the channel capacity is reduced or restricted, the tailwater at the structure will increase which will reduce the capability of the culvert which will typically increase flooding on the upstream side of the structure.

Where development is planned that may affect the department’s drainage systems, the development should be reviewed to ensure that the existing operation and conditions of departmental owned/controlled drainage structures is not adversely affected.
These reviews should not be limited to cross-drainage infrastructure and must include the following departmental drainage infrastructure:

- longitudinal drainage (table drains, kerb and channel and so on)
- diversion channels
- energy dissipation measures
- retention/detention basins
- levees
- catch banks/drains
- underground systems (pits and pipes) and subsoil drains
- water treatment/quality devices (including sediment basins)
- any other environmental protection device/measure related to drainage.

The department should check for:

- worsening of flood levels (afflux) upstream and downstream of the road
- any increase in the risk of water occurring on/overtopping the road
- any change in the risk of scour because of larger flows/higher velocities
- any increased risk of environmental harm or change in water quality.

As well as individual impacts, cumulative impacts should also be considered. These impacts are where the development currently being proposed is one of several (or many) that may occur. One individual development may not have an adverse impact, but further similar developments may be unacceptable when they are all combined.

Stormwater management reports should be received from developers, or consultants for developers, for all proposed developments where the runoff or flooding may affect a state-controlled road. These reports should be reviewed to assess the potential impacts and, if there are impacts, acceptable mitigation measures should be proposed.

Key requirements of these reports are:

- The flood report should be prepared by a suitably qualified and experienced consultant.
- The hydrologic and hydraulic modelling should be appropriate for the required assessment and should be described fully in the report.
- The analysis should calculate the flood discharges and flood levels for a range of AEPs (ARIs).
- The base case should calculate the flood discharges and levels for the existing conditions, and clearly show the results where the flow crosses the state-controlled road. It is possible that the base case shows that the road has a flood immunity that does not meet the departmental criterion, but the objective of this analysis is to show no worsening of drainage performance when compared to the base case.
- The developed case should include the proposed development and should calculate the flood discharges and levels at the state-controlled road.
• If there is an adverse impact, mitigation measures must be provided. Adverse impacts include an increase in flood discharge or flood level at the road. If there is an increase in flood level or discharge, but the road still maintains the required flood immunity, this may still be regarded as adverse, since other similar developments could make conditions worse. The flood discharges and levels for the mitigated case should be shown at the state-controlled road crossing and these must be no worse than for the base case.

• Mitigation measures may include detention basins, channel works, diversions or other works that ensure that the flood conditions are not worsened. It is important that mitigation measures at one crossing should not worsen conditions at other locations.

• The study should be supported by a comprehensive report that describes the analysis undertaken and presents assumptions with the results.

3.3.4 System augmentation

As stated in Section 3.1, the department must first determine or establish the hydrologic/hydraulic conditions at the site including the capacities (and immunity level) of any existing drainage infrastructure. When these existing conditions are compared to the drainage outcomes of any proposed development, the differences and potential impacts can be determined and understood.

In the event that the department believes that a proposed development will have adverse effects on its existing drainage infrastructure, a financial contribution from developers can be requested to allow the department to undertake appropriate work to augment or upgrade the existing drainage infrastructure in order to handle the changed conditions (hydrologic and/or hydraulic) caused by the development.

To allow discussion and negotiation in regard to any financial contribution from a developer, a reasonable basis for negotiation needs to be established. The following cases outline different situations that can, in turn, form the basis of discussion/negotiation with developers.

3.3.4.1 Case 1

If it is determined that the existing departmental drainage infrastructure meets current and planned (immunity and environmental) requirements and currently performs/operates satisfactorily, then any change required to the existing drainage infrastructure to enable it to adequately handle the changed hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.

3.3.4.2 Case 2

If it is determined that the existing departmental drainage infrastructure meets current and planned (immunity and environmental) requirements, but does not currently perform or operate satisfactorily, then the department would be responsible to undertake remedial work to enable the infrastructure to adequately perform/operate while any change required to the existing drainage infrastructure to enable it to adequately handle the changed hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.

3.3.4.3 Case 3

If it is determined that the existing departmental drainage infrastructure does not meet current or planned (immunity and environmental) requirements, then the changes required to the existing drainage infrastructure to meet current or planned (immunity and environmental) requirements is the responsibility of the department while any additional augmentation to the infrastructure required to
adequately handle any additional hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.