Environmental Flow Study Review for the Tarago and Bunyip Rivers

Melbourne Water

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Contents

1. Environmental Flow Study Review

1.1 Introduction

This report documents a review and update of ecological objectives and flow recommendations for the Tarago and Bunyip River, undertaken by an Environmental Flow Technical Panel (EFTP) and Melbourne Water.

In the original *Environmental Flow Determination for the Tarago and Bunyip Rivers* (EarthTech 2006a, 2006b, 2007) the Tarago and Bunyip River was divided into seven FLOWS reaches, as shown in Figure 1.1. Ecological objectives were developed for six of the seven reaches (Reaches 1 to 6) and flow recommendations subsequently developed for five reaches (Reaches 1, 2, 4, 6 and 7). A review of flow recommendations was completed in 2013 by SKM (2013a) but was limited to the reaches of the system where environmental water can be delivered i.e. downstream of Tarago Reservoir (Reaches 2 and 6). Table 1.1 provides a summary of the current state of ecological objectives and flow recommendations for the Tarago and Bunyip River Flow Reaches.

Table 1.1 : Tarago and Bunyip FLOWS Reaches.

Reach		State of Ecological Objectives and Flow Recommendations
1	Upper Tarago – Pederson Weir to Tarago Reservoir	Ecological Objectives: Developed in 2006/2007 (EarthTech 2006a, 2007).
		Flow Recommendations: Developed in 2007 (EarthTech 2007).
2	Lower Tarago – Tarago Reservoir to Bunyip River	Ecological Objectives: Developed in 2006/2007 (EarthTech 2006a, 2007).
		Flow Recommendations: Developed in 2007 (EarthTech 2007) and revised in 2013 (SKM 2013a).
3	Labertouche Creek	Ecological Objectives: Developed in 2006 (EarthTech 2006a)
		Flow Recommendations: None
4	Upper Bunyip – Bunyip State Forest to Tarago River	Ecological Objectives: Developed in 2006/2007 (EarthTech 2006a, 2007).
		Flow Recommendations: Developed in 2007 (EarthTech 2007) and revised in 2013 (SKM 2013a).
5	Cannibal Creek	Ecological Objectives: Developed in 2006 (EarthTech 2006a)
		Flow Recommendations: None
6	Lower Bunyip - Bunyip Main Drain	Ecological Objectives: Developed in 2006/2007 (EarthTech 2006a, 2007).
		Flow Recommendations: Developed in 2007 (EarthTech 2007) and revised in 2013 (SKM 2013a).
7	Bunyip Estuary	Ecological Objectives: Not developed in 2007/2007. Preliminary objectives documented in Tarago and Bunyip Rivers Environmental Water Management Plan (Melbourne Water & Jacobs 2017).
		Flow Recommendations: Developed in 2007 (EarthTech 2007).

In this 2018 study, the ecological objectives developed by EarthTech in their original 2006/2007 analysis have been extensively modified. The flow recommendations have then been revised in light of these revised ecological objectives.

Figure 1.1 : Tarago and Bunyip reaches for environmental water management. Reach 2 (Lower Tarago), Reach 6 (Lower Bunyip - Bunyip Main Drain) and Reach 7 (Bunyip Estuary) can receive environmental water. Source: VEWH (2016).

1.2 Technical review of flow recommendations

1.2.1 Scope of technical review

Each member of the EFTP completed a technical review of the flow recommendations and objectives as summarised in the *Tarago and Bunyip Rivers Environmental Water Management Plan* (Melbourne Water & Jacobs 2017) and with reference to earlier reports (EarthTech 2006a, 2006b, 2007, SKM 2013a). Noteworthy aspects that the review and update include:

- Results of fish monitoring conducted by ARI for the purposes of understanding the response of native fish to environmental flows, notably Australian Grayling and Tupong (ARI 2017);
- Results of recent River Blackfish monitoring findings (Ecology Australia 2017a) as well as a River Blackfish review that ARI is currently undertaking;
- Outcomes from recent projects on Cannibal Creek (Ecology Australia 2017b, GHD 2016a, Jacobs 2017a) and Labertouche Creek (Jacobs 2014);
- Insights from platypus surveys regarding population status, condition, recruitment success and links to specific flow patterns (Cesar 2015, Jacobs et al. 2016b);
- Additional water quality data (Melbourne Water 2017b) and updated hydrological data and models;
- Consideration of risks to values associated with extended dry climate conditions and maximum acceptable intervals between particular flow events;
- Investigations completed into the decommissioning of the Bunyip and Tarago Main Race (GHD 2016b, McGuckin 2010);
- Study investigating stormwater reuse opportunities in the Bunyip Basin (Alluvium 2017).
- Consolidation of vegetation objectives and clarification of the ecological functions of various flow components
- An explicit consideration of platypus, birds and frogs in flow recommendations; and
- Social and amenity values of water and development of flow requirements of water-dependent indigenous cultural values. The recent Bunyip and Tarago EWMP (Melbourne Water & Jacobs 2017) provides a brief description of social and amenity values and linkages with water-dependent indigenous cultural values. Amenity values are incorporated into generic objectives in each reach, but no specific flow recommendations have been developed for amenity values.

In recent years, there has been work undertaken to develop an understanding of groundwater surface water interactions in the Tarago and Bunyip Rivers (GHD 2015, SKM 2013b). This work helps us to understand the role of groundwater contribution to surface flow, gaining and losing reaches. A review of this work has not resulted in a change in the flow recommendations.

In addition, Melbourne Water raised a number of particular matters that the review should address:

1) Review the low flow recommendation of 12 ML/Day for Reach 2 (Lower Tarago) - could the flow recommendation be amended/appropriate?
2) Volume of water required to facilitate fish migration and results of recent monitoring that have shown that Grayling have spawned in years when current recommendations have not been met.
3) Preferences for movement of fish between the Lower Tarago (Reach 2) and Lower Bunyip / Bunyip Main Drain (Reach 6) as opposed to Upper Bunyip (Reach 4) and Lower Bunyip / Bunyip Main Drain (Reach 6) and implications for setting objectives and flow recommendations.
4) Partial achievement of Spring and Autumn high flow events and the additional volume of water that is needed to deliver the 2013 flow recommendations (Melbourne Water 2017a).
5) Concerns about sedimentation particularly in latter part of the year and how this may impact on Blackfish recruitment.

6) Duration of recommended events - is duration critical, if you have one day at recommended magnitude and flow volume is lowered on subsequent days is that sufficient, in delivering flow release is it better for flow to peak earlier or late? What is the importance of a break between events?

7) Ramp up/ramp down rates, particularly for Summer Fresh events? Would higher rates ramp up/ramp down rates be acceptable? Some releases have had to amend releases outside of the recommendations.

1.2.2 Changes to format and structure of ecological objectives and flow recommendations tables

In completing this review, we made a number of substantial revisions to the formatting and structure of the ecological objectives and flow recommendations originally developed by EarthTech (2006a, 2007). The changes were required for two reasons: (1) to make the objectives and recommendations more consistent with recent FLOWS updates for other systems in Victoria; and (2) to make the objectives, ecological functions, flow responses and recommendations internally consistent and more transparent to the reader. Highlights of the revisions include:

- Restructured ecological objectives tables to include the following column headings: Asset, Objective, No, Function, Flow component, Timing, Expected response and Response time.
- Restructured flow recommendations tables to include the following column headings: Season, Flow, Objective, Wet/Avg/Dry, Volume, Frequency and when, Duration, Rise/Fall. Flow components have also been colour coded to highlight those that are managed (blue) from those that are expected to naturally and hence not require active delivery (green).
- Revisions to the naming of seasons, flow components and their timing:
  - Season - Change from ‘Low flow season’ to Summer/Autumn (Dec-May) and ‘High flow season’ to Winter/Spring (Jun-Nov).
  - Flow components – Change from ‘Low flow fresh’ and ‘High flow fresh’ to Fresh.
  - Timing – Reference to Summer/Autumn or Winter/Spring period and calendar months for each flow component.

1.2.3 Changes to ecological objectives

A summary of changes to ecological objectives is presented in Table 1.2. Revised ecological objective tables and a more detailed description of changes is presented in Appendix A. Following is a brief summary of changes made:

- Revised wording and consolidation of geomorphology (physical form) and macroinvertebrate objectives. For macroinvertebrates, changes made capture assumed seasonal changes in low flows on macroinvertebrate biomass.
- Fish objectives have been revised so that the ‘Functions’ are more species specific, the ‘Timing’ of flow components refined and more measurable ‘Expected responses’ provided, where new supporting evidence exists, particularly for river blackfish, Australian grayling, tupong, eels and lamprey.
- Vegetation objectives have been restructured to reflect different vegetation habitats (instream, riparian, billabong/floodplain and terrestrial). ‘Functions’ and ‘Expected responses’ of flow components have been revised to make them accord better with revised objectives.
- New ecological objectives have been developed for platypus. Generic ecological objectives have also been included for Birds, Frogs and Amenity.

Table 1.2 : Summary of changes to ecological objectives.

Asset	Description of changes
Geomorphology	Geomorphology objectives have been revised and consolidated. Revised objectives and related 'Functions' and 'Expected Responses' have been developed so that they provided clear linkages with specific components of channel form and habitat (i.e. scour holes around large wood, pools).
Macroinvertebrates and Water Quality	Modified low flow objective and related 'Functions' and 'Expected Responses' so as to capture assumed changes in Summer / Autumn and Winter / Spring macroinvertebrate biomass production linked to inundation of habitat areas. Evidence suggests that winter biomass production is low compared with summer production due to cooler temperature conditions. To compensate for this a larger area of wetted habitat is required to maintain both primary (algal) and secondary (macroinvertebrate) production over the winter period. This is particularly important in streams supporting platypus because they have a high food demand, especially during winter and spring when females are gestating and lactating. Hence, winter requires higher base flows than summer in order to provide access to additional habitat. The 'Timing' of flow components has also been refined. Intent of 'Ecological Objectives' as they relate to specific habitats and processes is more clearly defined.
Fish	The 'Functions' associated with the 'Ecological Objectives' have been made more species-specific. New species-specific Functions have been developed, the associated Flow Timing refined, and more measurable 'Expected Responses' provided, where new supporting evidence exists, particularly for Australian grayling, tupong, eels and lamprey.
Vegetation	Vegetation objectives in the original EarthTech reports were re-evaluated and largely rewritten. First, the existing objectives were organised into separate sets of objectives for (a) in-stream, (b) riparian, (c) billabong/floodplain, and (d) terrestrial habitats. These were used as the explicit groups to structure all subsequent recommendations for vegetation. In order to clarify the objectives for riparian, floodplain and terrestrial vegetation, the most recent mapping of 2005 EVCs along each reach was viewed via the Biodiversity Interactive Mapsite. In some cases (e.g. EVC 83 Swampy Riparian Woodland), the vegetation present is listed as 'Endangered'. Accordingly, the Bioregional Conservation Status (BCS) of each EVC was considered when setting objectives. In some cases (e.g. Reach 6), this check of vegetation distributions resulted in a change in vegetation objectives. For some reaches it was not evident from available information that in-stream vegetation was present (e.g. Reach 4) whereas in others (e.g. Reach 5) indirect evidence pointed to the presence of such vegetation types (see Figure 1.4 below); in the former case it was assumed that there was some in-stream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped of riparian zone of EVC 18. and EVC 83. These were then included in the revised objectives. Melbourne Water's Seasonal Watering Proposal 2017/18 was also examined for clues as to how to make the updated vegetation objectives consistent with other MW and VEWH documents and strategies. Second, the ecological functions of various flow components were revised to make them accord consistently with the new objectives. This makes the objective-function relationship much more transparent to the reader. For example, in Reach 1 there are now six ecological functions identified that are required to meet the overarching objective of 'maintaining high quality in-stream, fringing and riparian vegetation'. In Reach 2, however, there is now the additional objective of preventing terrestrialisation of the stream channel and this resulted in the identification of seven specific vegetation functions to be addressed to meet the

Asset	Description of changes
	overarching objectives. Conversely, in Reach 6 the vegetation objectives are now limited to in-stream and fringing vegetation and only two ecological functions are identified. Third, the specific flow components and their timing to meet the various ecological functions were identified. Among the important changes is that the ecological functions of low-flows in the summer/autumn and winter/spring periods are now separated, whereas they were considered together in the original reports (despite them having different ecological functions). The differentiation between bankfull and overbank flows is also more consistent. Fourth, expected responses by vegetation were revised to make them accord more clearly with the now-internally consistent ecological functions of each flow component. The range of expected responses is much more exhaustive than in the original Earth Tech reports and has an explicit temporal component Fifth, a suite of complementary actions was devised for actions required to facilitate the desired vegetation objectives but involving activities other than the provision of environmental water: examples include fencing and grazing/browsing control. A focused literature review was undertaken to inform the length of inundation to drown-out terrestrial vegetation and to devise the best approach to minimising terrestrialisation via a combination of flow components. Recommendations for the duration of freshes and other high flows were also re-examined, and in some cases shortened if vegetation objectives could be met via other flow components. Consideration was also given to whether the rise and fall rates could be fastened without having adverse ecological outcomes, resulting in possible water savings and improved ease of delivery.
Platypus	EarthTech (2006a, 2007) did not include explicit consideration of platypus. This report has generated new ecological objectives and flow recommendations for platypus based on existing information on responses of platypus to particular hydrological regimes (where available) and expert knowledge of the species' biology and habitat requirements. A summary of habitat/flow requirements for platypus is included in the boxed section below.
Frogs, Birds and Amenity	Generic objectives have been included for Birds, Frogs and Amenity values

Habitat/flow requirements of platypuses

Platypuses are adaptable to a range of environmental conditions as demonstrated by the wide range of aquatic habitats and climatic zones they inhabit across their range (Grant 1992, Grant & Temple-Smith 1998). However, in broad terms, there are three key components required: permanent water, abundant macroinvertebrates, and stable earthen banks to construct burrows. Importantly, platypuses are highly mobile with individual home ranges and daily movements typically encompassing several kilometers (Griffiths et al. 2014, Gust & Handasyde 1995, Kelly et al. 2012, Otley et al. 2000, Serena et al. 1998a) and densities estimated at 1-2/km in a small creek around Melbourne (Serena 1994). Therefore, large contiguous areas of suitable habitat are required to support a self-sustaining platypus population. Population viability analysis (PVA) models have been used to estimate a minimum population size of 30 individuals is required for a platypus population to have a high probability of persisting for 50-100 years with moderate environmental stochasticity (Serena & Williams 1999), although a much larger population is required to avoid genetic problems in the longer term (Frankham et al. 2014, Soule 1980). Using 30 platypuses as a minimum population size and estimates of typical densities above, we estimate a stretch of at least 15-30 km of suitable contiguous habitat is required. The presence of off-stream (but connected) wetlands can increase the carrying capacity of an area (Serena 1994).

Critically, platypuses require adequate surface water and flow regimes to support a reliable supply of macroinvertebrate prey. Platypuses are adapted to feed exclusively in water where they forage for a range of benthic macroinvertebrates with adults consuming about 15-30% of their bodyweight daily (Holland & Jackson 2002, Krueger et al. 1992). Therefore, many habitat variables associated with platypus presence abundance are those favourable for macroinvertebrates. Platypuses are known to preferentially forage in areas of coarse benthic substrates (i.e. cobbles, rocks, pebbles) and large woody debris (Grant 2004, Serena et al. 2001). Other variables known to be important for platypuses include large riparian trees, overhanging vegetation, pools 1-3 m deep, and near vertical or undercut banks at least 0.5 m above the water (Bethge et al. 2003, Ellem et al. 1998, Grant 2004, Serena et al. 1998a, Serena et al. 1998b, Serena et al. 2001, Worley & Serena 2000). Conversely, platypuses are known to avoid areas of fine substrates (silt or clay) and dense willows (Serena et al. 2001).

The importance of suitable flow regimes for platypus is increasingly understood. Platypus distribution throughout Melbourne is known to be limited by catchment imperviousness (Martin et al. 2013, Serena & Pettigrove 2005) indicating that platypuses are sensitive to direct and indirect impacts of altered flow regimes of urban streams. Urban streams typically suffer from high flow variability with increased magnitude and frequency or high flows and reduced and extended baseflows. Generally, this leads to depauperate macroinvertebrate assemblages, increased erosion and sedimentation, and facilitates input of litter and pollutants from the surrounding catchment. High flow events may also increase foraging energetics for platypuses (Griffiths et al. 2014, Gust & Handasyde 1995). Reproduction in platypus has been linked with rainfall (and presumably reliable flows) in the months preceding breeding (March-July; Serena & Grant 2017, Serena et al. 2014), while late spring/summer floods may compromise juvenile recruitment (Bino et al. 2015, Serena et al. 2014)

Therefore, an ideal flow regime for platypuses would include (Jacobs 2017b):

1) maintaining minimum baseflow to maintain habitat for macroinvertebrates and longitudinal connectivity along stream for safe platypus movement;
2) moderate variability to support diverse macroinvertebrate community;
3) reliable surface water from March-July;
4) avoidance of bankfull or overbank flows during summer (November to February).

1.2.4 Changes to flow recommendations

Table B.1 in Appendix B presents a summary of the revised flow recommendations for the seven reaches, followed by summary tables for each of the reaches (Table B.2 to Table B.8). A summary of changes to flow recommendations is documented in Table 1.3. Revised flow recommendations tables and a more detailed description of changes are presented in Appendix C.

Following is a brief summary of changes made:

- Colour coding of flow components to highlight flows those that are managed (blue) from those that are natural (green)
- Revised objectives to include explicit reference to native fish species in each reach and specific reference to role of flows (i.e. Summer/Autumn freshes cue downstream migration of eels and may facilitate juvenile platypus dispersal).
- Review and update of flow recommendations (volume, frequency and when, duration and rise/fall) for wet/average and dry years.
- Rates of rise and fall have been reviewed for all reaches. The rate of rise has been increased to 2.2 as it sits between 50-80th percentile for all reaches; despite the increase in rate, this value is still conservative. In terms of rate of fall, there is a need to retain this slow value to prevent ecological impacts of more rapid drops in water levels. Hydrological analysis indicates that for all reaches 0.8 would be sufficient. For natural flow events, rates of rise/fall have been changed to N/A (not applicable) as there is no control over them.
- In Reach 2 the recommended Summer/Autumn low flow has increased from > 12 ML/day to 20 ML/day so as to provide additional depth and width of wetted bed/riffle (refer to Figure D.1 in Appendix D). The previous recommended Winter/Spring low flow (wet/average 100 ML/day and dry 86 ML/day) was considered too high, this has been lowered to 75 ML/day for wet/average and dry years. The reasons for the changes are two-fold:
  - Spells analysis indicates that a continuous Summer/Autumn low flow of 20 ML/day would have been expected naturally for wet/average years, although in dry years flow flows would have dropped below this threshold occasionally for several days (refer to Figure D.3 in Appendix D). At present a 12 ML/day passing flow at Drouin West exists in the Tarago and Bunyip Rivers Environmental Entitlement 2009. Raising the magnitude of the passing flow would assist in delivering the revised flow recommendation of 20 ML/day.
  - Both the existing and proposed revised recommended Winter/Spring low flow is rarely maintained throughout the season, with differences in spells for years presented in Figure D.4 and Figure D.5. Lowering the low flow from 86-100 ML/day to 75 ML/day still enables the ecological objectives to be met with more efficient use of available entitlement.
- Recommendations for the number and duration of freshes and other episodic high flows were also re-examined, and in some cases the number has increased but the duration of events has decreased. The change acknowledges that freshes and other episodic high flows have more ecological functions than those outlined in the original Earth Tech reports and that most of these can be achieved by shorter-term events (e.g. entraining organic matter, scouring riffles, facilitating fish movement, wetting the higher levels of the banks to encourage plant zonation). In these cases, increasing the number of events provides a degree of resilience in the expected response. Some desired ecological outcomes, especially the drowning of terrestrial vegetation, requires longer inundation periods during high-flow events. The principle matter where a reduction in the duration of freshes or other episodic high flows (e.g. bankfull flows) would be of concern is the duration required to drown-out terrestrial vegetation; as it was a controversial topic, this matter was examined in a rapid literature review and the outcomes summarised in the boxed section following Table 1.3. These considerations resulted in changes to the volume, timing and duration of Winter / Spring fresh recommendation in Reaches 2, 4 and 6. They result in a lower fresh in June or July to facilitate fish migration and a higher fresh between June and September to maintain flood-tolerant vegetation higher on banks. An illustration of the sequencing of recommended freshes and high flows in Reach 2 is presented in Figure 1.2 and Figure 1.3.
- Development of new flow recommendations for Reach 3 (Labertouche Creek) and Reach 5 (Cannibal Creek). Photographs of Cannibal Creek and excerpts of hydraulic models that were used to develop flow recommendations for this reach are presented in Figure 1.4 and Figure 1.5.

We have also reviewed a number of the notes that accompanied the previous flow recommendations tables, those notes and changes are summarised here:

- *7-day independence is recommended between events*. This earlier recommendation is maintained as it ensures that events are distributed throughout the flow season and not all delivered in one short burst which would meet the wording of flow recommendations but fail to deliver the desired environmental outcomes. For example, Summer/Autumn freshes assist in scour of sediments and maintenance of pools associated with large wood habitat. If all the recommended events were to be delivered over a single short period early in the season and none later, there may be undesirable consequences as the pools subsequently experience excessive sedimentation in the absence of the required flows.
- *Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every two years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.* This recommendation is maintained.
- *The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.* We have revised the use of the 'or natural' clause. For reaches which are largely unregulated the 'or natural' clause is included against all of the flow recommendations (i.e. Upper Bunyip, Labertouche, Cannibal), however, for strongly regulated reaches such Lower Tarago and Lower Bunyip / Bunyip Main Drain we have only included the "or natural" clause with the low flow recommendations.

Table 1.3 : Summary of changes to flow recommendations.

Reach		Description of changes
1	Upper Tarago – Pederson Weir to Tarago Reservoir	· Revised objectives to articulate role of flow components for range of water dependent values and include more explicit reference to native fish species, platypus, frogs and birds. Vegetation objectives revised and consolidated. · No change in recommended volume of Summer/Autumn low flow. · Revised frequency and duration of Summer/Autumn fresh for wet/average years (5 events, 1-2 days at peak) and dry years (3 events, 1-2 days at peak) · No change in recommended volume of Winter/Spring low flow. · Revised frequency of Winter/Spring fresh, with at least one event before Oct/Nov for broad-finned galaxias spawning and downstream transport of larvae. · Revised frequency of Bankfull flow to 1 event / year for wet/average years and Overbank flow to 1 event in 2-3 years for wet/average years (events not expected to occur in dry years).
2	Lower Tarago – Tarago Reservoir to Bunyip River	· Revised objectives to articulate role of flow components for range of water dependent values and include more explicit reference to native fish species, platypus, frogs and birds. Vegetation objectives revised and consolidated. · Previous recommended Summer/Autumn low flow considered too low. Increased low flow recommendation from > 12 ML/day to 20 ML/day, so as to provide additional depth and width of flow (increase in riffle area and access for platypus). · Revised volume, timing and duration of Summer / Autumn fresh for wet/average and dry years. Reduced volume from 100 ML/day to 75 ML/day and duration from 4 days to 2 days at peak. · Revised timing of Summer / Autumn high for wet/average years (1 event in April/May, every year) and dry years (1 event in April/May, must occur 2 in 3 years). Event in April/May to cue downstream migration of Australian grayling. · Previous recommended Winter / Spring low flow considered too high (wet/average 100 ML/day and dry 86 ML/day). Lowered volume of low flow for wet/average and dry years to 75 ML/day. · Revised volume, timing and duration of winter / spring fresh recommendation. Previous recommended fresh considered too high (280 ML/day). Changed from 1 Fresh for 4 days to two freshes in wet/average years, min 2 days at peak: 100-150 ML/day in June or July to facilitate migration of fish; and 200 ML/day between June and September - higher flow to maintain flood-tolerant vegetation higher on banks. In dry years, only one fresh in June or July with a lower volume of 100 ML/day. Second fresh between June and September not expected to occur in dry years. · New Winter/Spring high flow recommendation, provides prolonged disturbance to favour flood-tolerant vegetation. Wet/average years 300 ML/day and Dry years 200 ML/day, 2-3 days at peak, 7-10 days total duration. · No change in recommended bankfull and overbank flow recommendation. Removed earlier channel maintenance flow recommendation.
3	Labertouche Creek	· No hydraulic models are available for Labertouche Creek. Flow recommendations have been developed based on an analysis of flow duration curves and spells analysis of flow data from gauge.
4	Upper Bunyip – Bunyip State Forest to Tarago River	· Revised objectives to articulate role of flow components for range of water dependent values and include more explicit reference to native fish species, platypus, frogs and birds. Vegetation objectives revised and consolidated. · No change in recommended volume of Summer / Autumn low flow. · No change in recommended volume of Summer / Autumn Fresh. Revised frequency and duration of fresh for wet/average (5 events, 2 days at peak) and dry years (3 events, 2 days at peak).

Reach		Description of changes
		· Revised volume, timing and duration of Summer/Autumn high flow for wet/average and dry years. Reduced recommended volume from 175 ML/day to 50 ML/day. In wet/average years, 1 event in April/May, every year. In dry years, event required 2 in 3 years. · No change in recommended volume of Winter / Spring low flow. · Revised volume, timing and duration of winter / spring fresh recommendation. Previous recommended fresh 70 ML/day, 4 events including 1 in late Oct-Nov, 3 day duration. No change in recommended volume. Timing of freshes changed as for Reach 2. New Winter/Spring high flow recommendation, provides prolonged disturbance to favour flood-tolerant vegetation. · No change in recommended bankfull flow volume. Revised frequency and duration from 4 events, 3 day duration to 1 event, 2 day duration in wet/average years (not expected to occur in dry years). · No change in recommended volume of overbank flow. Revised frequency from 1 event / year to 1 event in 2-3 years and duration of 3 days to 1 day in wet/average years (not expected to occur in dry years).
5	Cannibal Creek	· Revised objectives to articulate role of flow components for range of water dependent values and include more explicit reference to native fish species, platypus, frogs and birds. Vegetation objectives revised and consolidated. · Flow recommendations have been developed with reference to recent investigations completed on Cannibal Creek (Ecology Australia 2017b, GHD 2016a, Jacobs 2017a). · Recommended Summer / Autumn low flow of 2 ML/day and 8 ML/day freshes. · Recommended Winter / Spring low flow of 8 ML/day and 20 ML/day freshes. · Recommended Bankfull flow of 50 ML/day and Overbank flow 100 ML/day.
6	Lower Bunyip - Bunyip Main Drain	· Revised objectives to articulate role of flow components for range of water dependent values and include more explicit reference to native fish species, platypus, frogs and birds. Vegetation objectives revised and consolidated. · No change in recommended volume of Summer / Autumn low flow. · No change in recommended volume of Summer / Autumn Fresh. Revised frequency and timing of fresh for wet/average and dry years so that it is consistent with Reach 2. · Revised volume and timing of Summer / Autumn high for wet/average and dry years. No change in recommended volume from EarthTech (2007) for wet/average years (200 ML/day). In dry years, lower recommendation of 150 ML/day. Event in April/May to cue downstream migration of Australian grayling. Event required 2 in 3 years, prioritise this. Revised recommended duration of peak of event from > 7 days to > 10 days duration (with extended duration of event provided by addional catchment inflows). A longer duration is considered important in the lower reaches for fish migration. · Revised recommend volume of Winter / Spring low flow to 50 ML/day throughout season. · Revised volume, timing and duration of winter / spring fresh and high flows, so that they translate with flow recommendations in Reach 2. · No change in recommended volume of channel maintenance flow.
7	Bunyip Estuary	· Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream.

Revisions to flow recommendation to prevent vegetation encroachment

The original EarthTech (2007) report assumed that a period of variously 2, 3 or 4 or 7 days inundation was adequate to disadvantage terrestrial plant species and to prevent their encroachment into the stream via episodic freshes (e.g. compare Tables 3.2, 3.4 and 3.8 of EarthTech 2007). These are mostly less than the period of 1−2 weeks considered necessary in more recent FLOWS studies to drown out terrestrial vegetation. The validity of an inundation duration of the 2−7 days and 1−2 weeks recommendations was discussed during the EFTP workshop, and a literature search was undertaken to clarify the matter.

The literature review indicated that the physiological consequences of prolonged inundation on vegetation are well understood at a conceptual level (Etherington 1982). Inundation can reduce or control encroachment by terrestrial species into freshwater streams (MIller et al. 2013) but its effectiveness is affected by a wide suite of factors, including preceding conditions, time of year, plant species and variety, stage of growth and life cycle of the targeted plants. Some terrestrial/riparian species are tolerant of prolonged inundation whereas others are highly sensitive to even minor flooding (e.g. see Cowie et al. 1996, Craine & Orians 2006, Esteban & Edwin 2016, Gerurts et al. 2005, Hare et al. 2004, Lenssen et al. 1998, Lynne & Waldren 2003, McDaniel et al. 2016, Shiferaw et al. 1992). In other words, there is no single inundation period for episodic freshes that can be guaranteed − or even expected − to reliably discourage the terrestrialisation of the stream channel.

In light of this finding, in this report a three-stage approach is recommended to prevent terrestrialisation of the stream channel, in-stream bars and lower banks. The first component is permanent inundation of the stream channel during summer/autumn. This low-flow component will result in most of the bed of the channel being permanently inundated (even if shallowly) and will strongly discourage the growth of unwanted terrestrial taxa. It is also critical in providing the permanent water required for in-stream submerged species that are intolerant of desiccation.

The second component is permanent inundation of the entire stream channel during winter/spring. Like the comparable summer/autumn low-flow, it is critical also in providing the permanent water required for in-stream submerged species that are intolerant of desiccation. This low-flow component, however, will also discourage the germination and establishment of terrestrial plants on in-stream bars and on the lower banks because they will be constantly under water over the winter-autumn period and few if any terrestrial taxa can recruit under these conditions. It will also strongly discourage the growth of unwanted terrestrial taxa on lower levels of the banks, as the recommended winter/spring low flow is usually greater than the summer/autumn low flow (e.g. in Reach 1, >10 ML/Day in summer/autumn versus 35 ML/day in winter/spring).

The third component utilises periodic inundation via short-term freshes and other episodic high flows (e.g. dedicated High Flows or bankfull flows) with longer effective durations or creating more severe ecological disturbance. The ecological function of some of these events can be met by short-term (i.e. 2 days) inundation; e.g. facilitating fish passage, ensuring vegetation zonation and cleaning out riffles. Other ecological functions require longer periods of inundation, especially the drowning-out of terrestrial vegetation. The difference is shown in Figure 1.3 below, where the second winter fresh effectively extends over 7-10 days in total including rise and fall times. These episodic high flow events should be seen as a complement to the main effect of the permanent inundation occasioned by the summer/autumn and winter/spring low flows. The literature suggested that a 7 to 14-day period of inundation (preferably longer rather than shorter) via freshes is a reasonable compromise between the conflicting periods identified in the various studies. Inundation of this duration will likely help limit terrestrialisation by herbs, forbs, grasses and trees/shrub species. Freshes are also important in maintaining vertical zonation of aquatic and fringing vegetation up the banks because they maintain flood-tolerant plants at various elevations above base flow. For this outcome, however, the freshes need be of shorter duration as all they have to achieve is to thoroughly wet the soils, not inundate or drown-out encroaching terrestrial vegetation. Two days duration should be sufficient for this purpose, in contrast to the longer periods required to drown-out terrestrial plants. Monitoring is strongly recommended to test the recommendation, as the literature review was not unequivocal in its findings and there were few published reports that explicitly quantified the optimal duration to prevent encroachment.

In summary, permanent inundation via the summer/autumn and winter/spring low flows (i.e. all year) is critical in preventing terrestrialisation of the stream channel, in-stream bars and lower banks. These two flow components achieve this outcome by having the stream channel, or a large proportion of it, fully inundated all year. Freshes and other longer-duration high-flow events, especially in winter/autumn, can help with preventing terrestrialisation. But there are great differences across plant species, growth stages and preceding conditions in the inundation duration required to be effective. Bankfull flows are, in theory, useful in creating stream-scale disturbance and preventing terrestrialisation, but observations of streams elsewhere in Victoria suggests that bankfull flows often result only in the temporary pushing-over of terrestrial or tall emergent plants (e.g. reeds and cumbungi) and that exceptionally high flow velocities are required to physically uproot established stands.

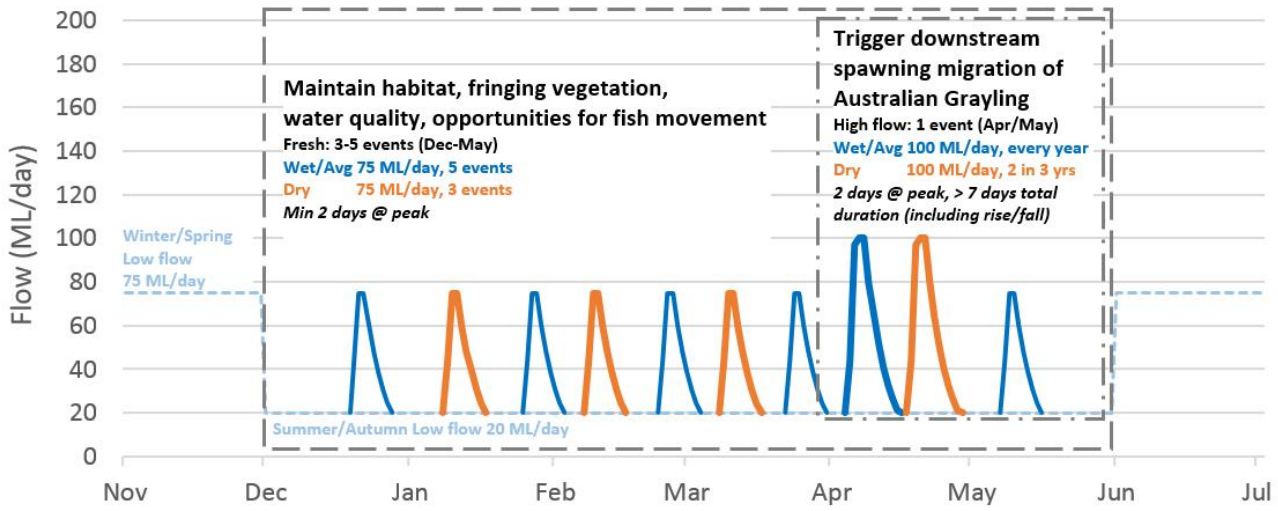

Figure 1.2 : Schematic illustrating Reach 2 flow recommendations for Summer/Autumn Fresh and High flows in wet/average and dry years.

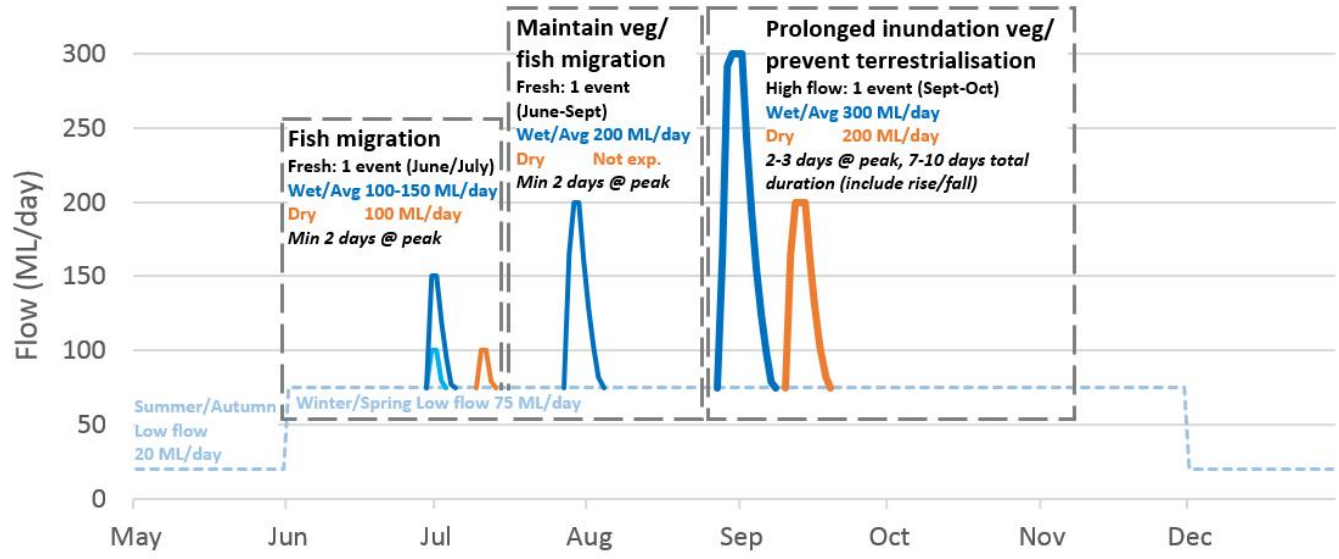

Figure 1.3 : Schematic illustrating Reach 2 flow recommendations for Winter/Spring Fresh and High Flows in wet/average and dry years.

Figure 1.4 : Photographs of Cannibal Creek at Wimpole Road Site for which a HEC RAS model has been developed and flow monitoring has been undertaken (Refer to Figure 1.5). Top: Creek at XS3 showing bench that we recommend is periodically inundated by Summer/Autumn freshes and continuous inundation with Winter / Spring low flow. Bottom: Creek at XS5 which is located upstream of XS3 and is representative of a typical pool in this reach.

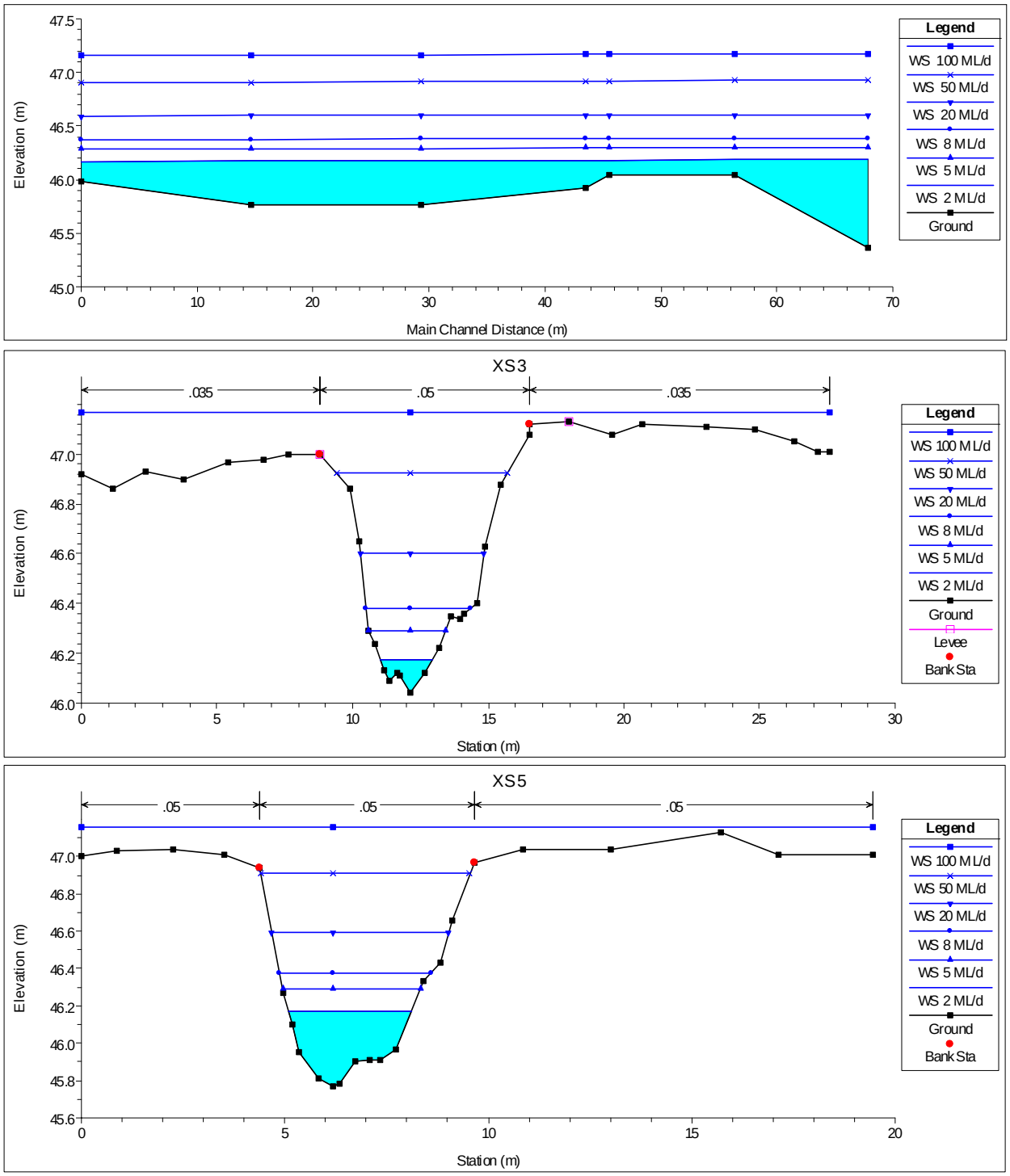

Figure 1.5 : Long section profile and cross sections from HEC-RAS model for Cannibal Creek at Wimpole Road Site showing water level and depths associated with recommended flow rates for Summer / Autumn (low flow 2ML/day, fresh 8 ML/day) and Winter / Spring (low flow 8 ML/day, fresh 20 ML/day, bankfull 50 ML/day and overbank flow 100 ML/day). XS3 coincides with a riffle at the downstream end of pool, channel distance 46 m (10-15 cm water depth with Summer/Autumn low flow of 2 ML/day, 8 ML/day Summer/Autumn fresh and Winter/Spring low flow inundate bench). XS5 is positioned within the pool, channel distance 15 m (30-40 cm water depth with Summer / Autumn low flow and 50-60 cm water depth with Winter / Spring low flow). Review of prioritisation of environmental flow objectives under varying climatic scenarios.

1.2.5 Analysis of revised flow recommendations, compliance and shortfalls for various management scenarios

1.2.5.1 Climate year classification

Table 1.4 presents percentage of climate years that were defined as the same when using rainfall versus inflow, and rainfall versus streamflow for Reach 2. It can be seen the highest correlation of 82% has been determined for dry years when comparing rainfall and inflows versus climate years. This is because the antecedent catchment conditions impact the resulting inflow, with lower rainfall generally occurring when catchment is drier. In comparison the dry year comparison for the rainfall and streamflow reduces to 53% streamflow comparison. This reduction is because of regulation present in the river system. Alternatively, 71% of wet years were defined the same when using rainfall and streamflow, compared with 65% when applying inflows. As increased rainfall is experienced in the upper catchment of the Bunyip and Tarago systems, the likely downstream flows will be greater because of the higher runoff of nearby catchments but also increased spill events form the Tarago Reservoir.

Table 1.4 : Comparison of climate year classification between rainfall, inflow and streamflow for Reach 2 (as a percentage).

Climate Year	Rainfall and Inflow (%)	Rainfall and Streamflow (%)
Dry	82%	53%
Average	50%	44%
Wet	65%	71%

It should be noted that similar analysis was performed for Reach 5, with results showing similar findings.

Based on this analysis it can be seen that catchment conditions and regulation have a significant impact on the year classification. It is recommended that inflow rather than streamflow or rainfall is used to define climate years. This will ensure consistency with other groups in Melbourne Water, such as the Water Resources group who use inflow to specify climate years for making water supply management plans. Using streamflow at the compliance point, it is likely that dry years would be managed more frequently than the other average/wet scenarios due to the impact of regulation, which is not ideal. On the other hand, rainfall represents the climate conditions but does not consider antecedent catchment conditions, unlike inflows.

1.2.5.2 Historical compliance and shortfall assessment

Compliance and shortfalls on the Tarago – Bunyip system (i.e. Environmental Flow Reaches 2 and 6) were calculated using the historical flow regime (i.e. gauged data). The flow scenarios were then assessed to see how well the flow regimes complied with the revised environmental flow recommendations. It should be noted that classification of climate years was undertaken using inflows and dividing equally into three parts (with very dry years included in the dry years category), while shortfalls were calculated as the volume required to meet environmental flow volume requirements. Inflows was chosen in order to be consistent with the other Water Resources groups within Melbourne Waters (for further details see previous section), also, Inflow also provides a better representation of actual climate conditions because unlike streamflow, inflow is not impacted by or regulation / extraction.

As seen in Table 1.5, compliance is generally met for majority of the Winter/Spring flow recommendations bar the low flows for Reach 2. On the other hand, in Summer/Autumn compliance is less, for all flow recommendations. A similar trend is found in Reach 6, with Winter/Spring results suggesting that compliance is better and shortfall decreasing. This is due to the catchment runoff and tributary flows in the Bunyip catchment contributing to the streamflows, thereby meeting the required recommendations. Despite the better compliance and shortfall assessment in Reach 6, both reaches have been impacted by the Millennium Drought, particularly between 2005 and 2010, where the compliance for majority of the flow recommendations is either partially met or not met at all, such as the Autumn High. This would have significant impact on Australian Grayling which relies on provision of an Autumn High every 2 to 3 years to ensure the survival of this species.

Table 1.5 : Compliance with revised environmental flow recommendations under historical (gauged) and for wet, average and dry climate type years for the Tarago - Bunyip River environmental flow Reach 2 and Reach 6 noting that environmental flow recommendations differ between wet, average and dry climate years.

Reach 2 - Tarago River at Drouin West (228201)										
Condition	Year	Summer / Autumn Low Flow	Summer / Autumn Fresh	Summer / Autumn High	Winter / Spring Low Flow	Winter / Spring Fresh (June-July)	Winter / Spring Fresh (June-Sept)	Winter / Spring High	Bankfull	Overbank
A	1968	2018	330	0	2453	0	0	0	0	953
A	1969	800	330	0	4688	0	0	0	0	953
W	1970	161	110	0	6	0	0	0	0	0
W	1971	359	110	0	499	0	0	0	0	0
A	1972	696	330	160	8594	50	0	450	553	953
A	1973	549	220	0	2595	0	0	0	553	953
W	1974	613	330	0	1840	0	0	0	0	0
W	1975	697	330	160	1989	0	0	0	0	0
W	1976	552	440	160	4805	50	0	0	0	953
W	1977	135	110	0	2314	0	0	450	0	0
W	1978	349	440	0	1294	0	0	0	0	0
D	1979	236	0	160	6692	50		0		
A	1980	541	550	160	5242	0	0	450	0	953
A	1981	724	330	0	4427	0	0	0	0	953
D	1982	589	220	160	8187	0		0		
A	1983	669	550	160	4557	0	0	0	0	953
W	1984	647	330	0	2846	0	0	0	0	0
W	1985	379	440	160	2120	0	0	0	553	953
W	1986	423	330	0	1628	0	0	0	0	0
A	1987	491	220	160	3500	0	0	450	0	953
A	1988	373	440	160	6285	50	0	450	0	953
A	1989	191	0	160	1496	0	0	0	0	0
W	1990	514	440	0	3598	0	0	0	0	0
A	1991	715	440	160	2512	0	0	0	0	0
W	1992	42	330	0	438	0	0	0	0	0
W	1993	32	330	160	1546	0	0	0	0	0
A	1994	1	0	160	2658	50	0	0	0	953
W	1995	0	110	0	144	0	0	0	0	0
W	1996	0	220	0	727	0	0	0	0	0
D	1997	0	220	160	2184	0		250		
A	1998	0	440	0	979	0	0	0	553	953
D	1999	0	0	0	1491	0		0		
D	2000	14	0	0	841	0		0		
D	2001	0	220	0	3216	0		0		
D	2002	0	0	0	2544	0		250		
D	2003	338	330	160	5229	0		0		
D	2004	0	110	0	287	0		0		
D	2005	0	0	0	4002	50		0		
D	2006	0	110	160	7631	50		250		
D	2007	247	0	160	8743	50		250		
D	2008	426	0	160	5767	50		250		
D	2009	651	110	160	6970	50		0		
W	2010	483	550	160	4090	50	0	0	553	953
W	2011	3	110	0	224	0	0	0	0	0
A	2012	0	110	0	1118	0	0	0	0	0
A	2013	463	220	0	1482	0	0	0	553	953
A	2014	228	110	0	640	0	0	450	0	953
D	2015	35	0	0	3476	0		0		
D	2016	193	0	0	2129	0		0		

Reach 6 - Bunyip River at Iona (228213)									
Condition	Year	Summer / Autumn Low Flow	Summer / Autumn Fresh	Summer / Autumn High	Winter / Spring Low Flow	Winter / Spring Fresh (June-July)	Winter / Spring Fresh (June-Sept)	Winter / Spring High	Channel Maintenance
A	1968	4846	280	0	0	0	0	0	0
A	1969	787	0	0	0	0	0	0	0
W	1970	31	140	0	0	0	0	0	0
W	1971	97	280	0	0	0	0	0	0
A	1972	0	140	0	8	0	600	0	1450
A	1973	243	0	0	0	0	0	0	0
W	1974	341	0	0	0	600	0	0	0
W	1975	11	0	0	0	0	0	0	0
W	1976	11	280	300	0	0	600	0	0
W	1977	16	0	0	0	0	0	0	0
W	1978	175	0	0	0	0	0	0	0
D	1979	0	0	0	0	600		0	
A	1980	841	560	300	0	0	0	1900	0
A	1981	373	280	0	0	0	0	0	0
D	1982	362	0	0	137	0		1300	
A	1983	1196	420	300	0	0	0	0	0
W	1984	633	140	0	0	0	0	0	0
W	1985	797	420	0	0	0	0	1900	0
W	1986	745	0	0	0	0	0	0	0
A	1987	146	280	0	0	0	0	1900	0
A	1988	1088	140	300	71	0	0	0	0
A	1989	331	0	300	0	0	0	0	0
W	1990	381	420	0	0	0	0	0	0
A	1991	329	140	300	15	0	0	0	0
W	1992	0	140	0	0	0	0	0	0
W	1993	0	560	0	0	0	0	0	0
A	1994	0	560	0	0	0	0	0	0
W	1995	0	420	0	0	600	0	0	0
W	1996	0	560	0	0	0	0	0	0
D	1997	0	280	0	0	0		1300	
A	1998	0	0	0	0	0	0	1900	1450
D	1999	0	0	0	0	600		0	
D	2000	11	0	0	0	0		0	
D	2001	19	0	0	0	0		0	
D	2002	0	0	0	4	600		1300	
D	2003	178	280	200	61	0		0	
D	2004	0	0	0	0	0		0	
D	2005	0	0	0	0	600		0	
D	2006	0	0	0	409	600		1300	
D	2007	435	280	200	464	600		1300	
D	2008	2507	280	200	389	600		1300	
D	2009	546	140	200	65	600		0	
W	2010	748	420	300	0	0	600	0	0
W	2011	0	560	0	0	0	0	0	0
A	2012	0	560	0	0	600	0	0	0
A	2013	222	0	0	0	0	0	0	0
A	2014	11	0	0	0	0	0	1900	0
D	2015	6	0	0	0	0		0	
D	2016	60	0	0	0	0		0	

Legend

Mostly complies		Greater than	95%		
Frequently complies		Between	75%	&	95%
Often complies		Between	50%	&	75%
Occasionally complies		Between	25%	&	50%
Rarely complies		Between	5%	&	25%
Never complies		Between	0%	&	5%

Similar results have been found when comparing the compliance assessment documented in this report for the revised flow recommendation with the compliance assessment documented in the Tarago and Bunyip Rivers Environmental Water Management Plan, which assessed existing flow recommendations (Jacobs 2017c). For example, in Reach 2, post 1992 summer low flows are being met same as for the existing flow recommendations. However, there have been improvements in compliance and reductions in shortfalls with the revised winter flow recommendations. This is particularly evident in the winter freshes, due to the changes in the flow recommendations from a 280ML/day at 5-day duration to 75 ML/day at 2-day duration fresh event. Reach 5 showed very similar compliance outcomes, with freshes and low flows being met the majority of the time as the contribution from catchment runoff aids in meeting the required thresholds.

Environmental Entitlement Assessment

The average compliance and shortfall pre and post the introduction of the Environmental Entitlement (EE) and delivery of environmental flows in 2012, in the Reaches 2 and 6 for each year type were analysed and are presented in Table 1.6. It can be seen in Reach 2 that compliance in both dry and average years improves, with average reductions in shortfalls across all components of 350 ML and 565 ML for dry and average years respective. A similar trend is found in Reach 6 with average reduction of shortfall in dry and average years of 235 and 77 ML, respectively. It should be noted that wet years pre and post the introduction of the EE could not be assessed as there were no wet years post 2012.

Additionally, it can be seen that a reduced shortfall does not necessarily equate to an increase in compliance. This is because of how compliance has been defined (e.g. frequently occurs ranges between 75-95%). The years since the EE was enacted tend to correspond to dry and average climate years when compliance is not as good, so the benefit of the EE is much more evident. This suggests and demonstrates that the intended use of the EE, that is, to protect flows particularly during dry years, is being achieved.

Table 1.6 : Compliance with revised environmental flow recommendations under historical (gauged) and for wet, average and dry climate type years for the Tarago - Bunyip River environmental flow Reach 2 and Reach 6, pre and post the first release from the EE (i.e. 2012), noting that environmental flow recommendations differ between wet, average and dry climate years.

			Summer / Autumn Low Flow	Summer / Autumn Fresh	Summer / Autumn High	Winter / Spring Low Flow	Winter / Spring Fresh (June-July)	Winter / Spring Fresh (June-Sept)	Winter / Spring High	Bankfull	Overbank	Channel Maintenance
Reach 2	Pre 2012	D	179	94	91	4556	21		89			
		A	598	322	98	3845	12	0	138	128	806	
		W	317	298	47	1771	6	0	26	65	168	
	Post 2012	D	114	0	0	2802	0		0			
		A	230	147	0	1080	0	0	150	184	635	
		W										
Reach 6	Pre 2012	D	290	90	57	109	343		557			
		A	783	215	115	7	0	46	438			223
		W	235	255	35	0	71	71	112			0
	Post 2012	D	33	0	0	0	0		0			
		A	78	187	0	0	200	0	633			0
		W										

Legend

Mostly complies		Greater than	95%		
Frequently complies		Between	75%	&	95%
Often complies		Between	50%	&	75%
Occasionally complies		Between	25%	&	50%
Rarely complies		Between	5%	&	25%
Never complies		Between	0%	&	5%

Dam Operation Assessment

The average compliance and shortfall for different Tarago reservoir operational periods for Reaches 2 and 6 is given in Table 1.7. From 1991 to 2002, the reservoir had generally been maintained at levels between 155.40 m AHD (or 29,000 ML) and 156.00 m AHD (or 31,000 Ml) to minimise the risk of regular overflows, primarily to avoid impacts to a caravan park adjacent to the Tarago River. In September 2002, the operating levels were revised and made more stringent, resulting in a reduction in compliance in dry years, however an increase in compliance in wet years as shown in Table 1.7. This is most likely due to higher frequency of spills occurring in wet years as the maximum operating level reduced. In 2012 works were undertaken such that the dam can be operated at Full Supply Level (FSL) once again, with the EE introduced in addition in this time (see Table 1.6). In dry years for both reaches, the compliance improves and shortfall decreases with the introduction of the EE. On the other hand, when we compare average years to the 1992-2002 period it can be seen that compliance slightly reduces. This is because the maximum operating level has increased post 2012, and as such the number of spills reduces.

Table 1.7 : Compliance with revised environmental flow recommendations under historical (gauged) and for wet, average and dry climate type years for the Tarago - Bunyip River environmental flow Reach 2 and Reach 6, for different dam operational periods noting that environmental flow recommendations differ between wet, average and dry climate years.

			Summer / Autumn Low Flow	Summer / Autumn Fresh	Summer / Autumn High	Winter / Spring Low Flow	Winter / Spring Fresh (June-July)	Winter / Spring Fresh (June-Sept)	Winter / Spring High	Bankfull	Overbank	Channel Maintenance
Reach 2	1992-2002	D	3	88	32	2055	0		100			
		A	239	293	107	2050	17	0	0	184	635	
		W	19	248	40	714	0	0	0	0	0	
	2003 - 2011	D	237	94	114	5519	36		107			
		A										
		W	243	330	80	2157	25	0	0	276	476	
	2012 - 2016	D	114	0	0	2802	0		0			
		A	230	147	0	1080	0	0	150	184	635	
		W										
Reach 6	1992-2002	D	6	56	0	1	240		520			
		A	110	233	100	5	0	0	633			483
		W	0	420	0	0	150	0	0			0
	2003 - 2011	D	524	140	114	198	429		557			
		A										
		W	374	490	150	0	0	300	0			0
	2012 - 2016	D	33	0	0	0	0		0			
		A	78	187	0	0	200	0	633			0
		W										

Legend

Mostly complies		Greater than	95%		
Frequently complies		Between	75%	&	95%
Often complies		Between	50%	&	75%
Occasionally complies		Between	25%	&	50%
Rarely complies		Between	5%	&	25%
Never complies		Between	0%	&	5%

1.2.5.3 Review of volumes required to meet revised flow recommendations

The volume required to meet the revised flow recommendations were based on the historical shortfall analysis presented in the previous section, with volumes for each scenario for Reach 2 (Table 1.8) and Reach 6 (Table 1.9). Of note, the volumes presented are based on ideal conditions where there is no losses or other factors influencing the delivery of environmental water considered. In practice it is expected that these volumes will be larger.

Table 1.8

It can be seen that for Reach 2 water required to meet all of the revised flow recommendations are higher in very dry years versus dry years. This is expected since streamflows in very dry years are much lower than dry years. In average years, water requirements are larger than that for wet years. This is because average years have lower streamflows compared with wet years. Additionally, it can be seen that for low flows, the volume required to meet these recommendations is by far the largest compared with the other recommendations, particularly in winter spring. However, these have not been included in the final total as the Tarago - Bunyip EE does not have to ensure these recommendations are meet.

In terms of Reach 6, a similar trend is found, however volumes are smaller because of the contribution of other inflows from catchment runoff and tributary flows. Of note, the volumes presented are based on ideal conditions where there is no losses or other factors influencing the delivery of environmental water considered. In practice it is expected that these volumes will be larger.

Table 1.8 : Volume of water (in ML) required to meet each environmental flow recommendation to Reach 2 based on the shortfall assessment for different climate years.

Climate Year	Summer Autumn			Winter Spring				Bankfull	Overbank	Total[1]
	Low flow	Fresh	High	Low flow	Fresh (Jun–Jul)	Fresh (Jun–Sep)	High			
Very Dry	279	110	160	8187	33		167			470
Dry	146	76	62	3448	15		58			211
Average	529	289	80	3327	9	0	141	138	774	519
Wet	317	298	47	1771	6	0	26	65	168	377

[1]Total volume does not include bankfull, overbank and low flows volumes

Table 1.9 : Volume of water required to meet each environmental flow recommendation to Reach 6 based on the shortfall assessment.

Climate Year	Summer Autumn			Winter Spring				Bankfull	Overbank	Total[1]
	Low Flows	Fresh	High	Low Flows	Fresh (Jun–Jul)	Fresh (Jun– Sep)	High			
Very Dry	981	187	133	421	600		1300		5628	2220
Dry	91	54	31	20	231		300		2728	615
Average	651	210	94	6	38	38	475	181	3680	854
Wet	235	255	35	0	71	71	112	0	2764	544

[1]Total volume does not include bankfull or overbank volumes

1.2.5.4 Review of available entitlement based on 10.3% of inflows

Recently, there has been an update to the environmental water recommendations and requirements in the Tarago and Bunyip River system. Seasonal scenario planning procedures have been introduced aiming to plan for different future scenarios in order to guide waterway manager's decision making. Scenarios range from very dry to wet climate years (refer to Section 1.2.6). To facilitate and inform within year environmental

watering decisions under these different scenarios, a review of the Tarago inflows and Environmental Entitlement (EE) has been under taken. To determine available Tarago and Bunyip Rivers EE qualified in 2011, with the first release occurring in 2012, Melbourne Water use an environmental water accounting model which considers:

i. a 3,000 ML share of the Tarago Reservoir;

ii. 10.3 % of the net inflow to Tarago Reservoir after passing flows have been met; and

iii. Meeting 12 ML/day passing flows at Drouin West.

Observed cumulative rainfall, inflows and EE from the environmental water accounting model for representative very dry, dry, average and wet years are presented in Figure 1.6, Figure 1.7 and Figure 1.8, respectively. It can be seen in Figure 1.6 that in very dry years, the cumulative rainfall increases until it reaches a maximum 600 mm/year. This is different to the very wet year, where the total rainfall was approximately 1,100 mm/year in 2010/11. The long term average rainfall is close to another dry year (1990/91), indicating that Tarago is on average a dry catchment, with this water year (2017/2018) following a similar trend to the long-term averages.

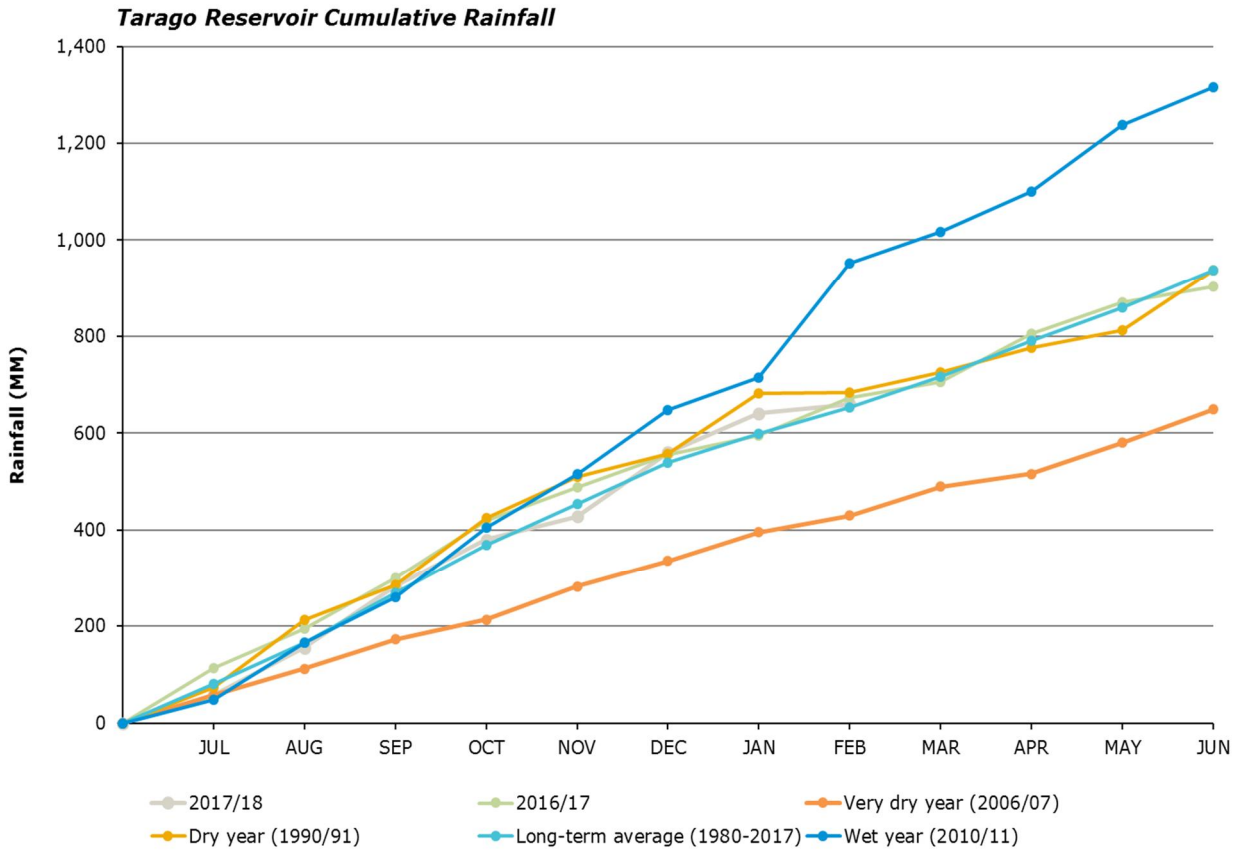

Figure 1.6: Cumulative rainfall at Tarago Reservoir under different scenarios (very dry to wet years)

In comparison, Figure 1.7 shows the associated streamflow into Tarago Reservoir. It can be seen that for very dry and wet years total streamflow volume ranges from approximately 10,000 to 50,000 ML. However, unlike the rainfall, streamflow for dry and average water years is varied, with long term averages being approximately 27,000 ML/year. This is because streamflow is impacted by catchment condition. For instance, Ii the upper catchment in the Tarago system is dry, then runoff into the reservoir is smaller.

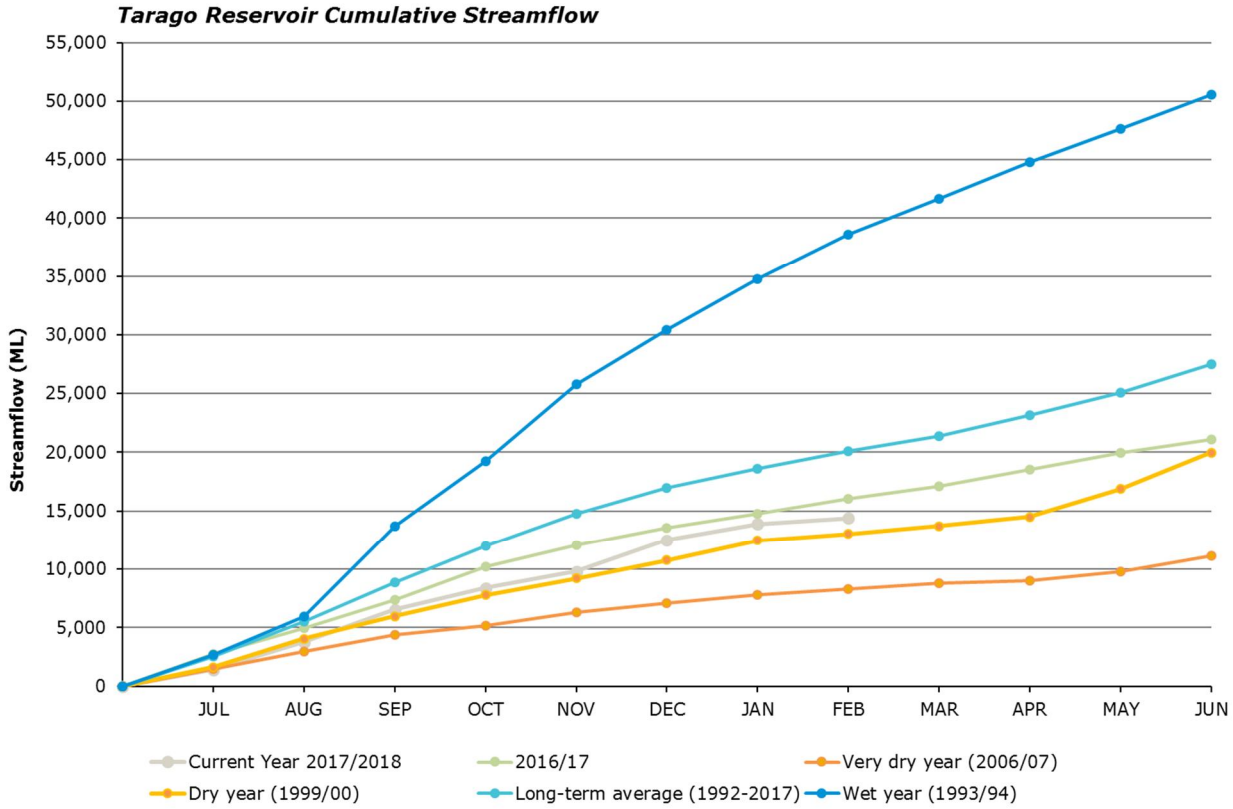

Figure 1.7 : Cumulative streamflow at Tarago Reservoir under different scenarios (dry to wet years)

Figure 1.8 shows the Tarago EE based on the cumulative 10.3% net inflows for different scenarios. It can be seen that the EE steadily increases until reaching the maximum EE of approximately 1,600 to 3,900 ML/year for dry and wet years, with long term averages suggesting that approximately 2,600 ML/year will become available. In addition to this, the variation in EE for the average and dry years is more evident compared with the streamflows in Figure 1.7. This is due to the impact of operation and legislative arrangements, including meeting passing flows as well as the 3,000 ML share. The information also presents how the EE will change throughout the different scenarios (i.e. dry versus wet year), which will inform whether there will be enough volume in the EE account to target for instance a Summer fresh or hold off until Autumn and target a high flow and promote Australian Grayling Spawning.

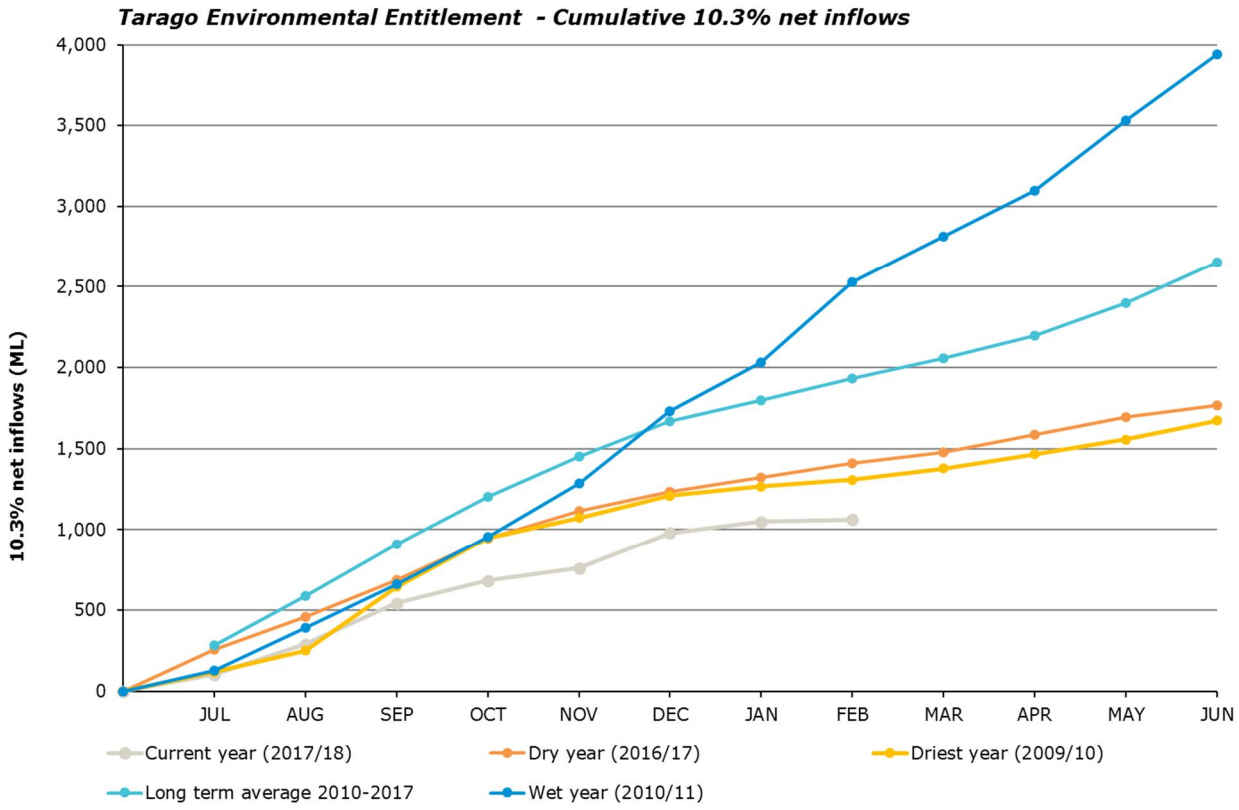

Figure 1.8 : Cumulative Tarago and Bunyip Environmental Entitlement different scenarios (dry to wet years)

1.2.6 Prioritisation of watering actions

Environmental water delivery is monitored and adaptively managed as conditions unfold throughout the year. Four management scenarios have been developed to cover a range of possible climatic conditions for the system. The scenarios and recommended watering actions associated with them are based on historic streamflow in Reach 2.

The previous prioritisation of watering actions for different climate scenarios documented in the *Tarago and Bunyip Rivers Environmental Water Management Plan* (Melbourne Water & Jacobs 2017) has been revised following the review and update of ecological objectives and flow recommendations.

It is recommended that there is a slight change in the water year classification for the very dry, dry, average and wet watering actions so there is consistency with the split in climate years used for the development of flow recommendations. The environmental flow recommendations have been developed using a lower third (dry), middle third (average) and highest third (wet) split. It is proposed that this split is used, with the lower third, potentially broken down into two categories very dry and dry.

Revised priority water actions and environmental objectives are presented in Table 1.10. During very dry and dry conditions highest priority is the delivery of Summer / Autumn freshes as required to provide relief from long periods of low streamflow and protect priority species and refuge habitat.

The delivery of an Autumn high to trigger downstream spawning migration of Australian Grayling is also recommended. It is preferred that this event is delivered every year, if possible. If there are more than two years without Autumn high, it is recommended that this spawning event is prioritised in third year. These events should be prioritised over a Winter / Spring fresh for recruitment, as without spawning there might not be any recruits. If Autumn high event does occur, next priority is Winter/Spring fresh.

Table 1.10 : Delivery of priority watering actions under a range of potential seasonal condition or water availability scenarios.

	Protect (Very dry: Lowest 5th percentile of flows)		**Maintain** (Dry: Between 5th and 33th percentile of flows)		**Recover** (Average: Between 33th and 66th percentile of flows)		**Enhance** (Wet: Highest 66th percentile of flows)	
Expected water availability	**Carryover** 1,500 ML	**Inflows** 200 ML	**Carryover** 1,500 ML	**Inflows** 500 - 1,000 ML	**Carryover** 1,500 ML	**Inflows** 1,000 - 2,200 ML	**Carryover** 1,500 ML	**Inflows** 2,300 – 3,500 ML
Watering actions to be delivered	1. Summer / autumn freshes as required to provide relief from long periods of low streamflow		1. Summer / autumn freshes as required to provide relief from long periods of low streamflow 2. Autumn high to trigger downstream spawning migration of Australian Grayling (Apr/May, 1 event required 2 in 3 years, priority) 3. Winter / spring fresh for fish migration (Jun/Jul, 1 event)		1. Summer / autumn freshes to maintain habitat, vegetation, water quality 2. Autumn high to trigger downstream spawning migration of Australian Grayling (Apr/May, 1 event every year) 3. Winter / spring freshes for fish migration and vegetation (Jun-Sep, 2 events)		1. Summer / autumn freshes to maintain habitat, vegetation, water quality 2. Autumn high to trigger downstream spawning migration of Australian Grayling (April/May, 1 event every year) 3. Winter / spring for fish migration and maintain vegetation (Jun-Sept, 2 events) 4. Winter / spring high to discourage terrestrial vegetation (Sep/Oct, 1 event). Bankfull and overbank may occur naturally but will not be provided.	
Environmental objectives	· Protect priority species and critical refuge habitat · Prevent localised extinctions and catastrophic events, such as fish kills. · Protect water quality to prevent adverse impacts on priority species and habitats		· Protect priority species and critical refuge habitat · Prevent localised extinctions and catastrophic events, such as fish kills · Protect water quality to prevent impacts on priority species and habitats		· Improve access to suitable habitat for priority fauna · Protect against flow related declines in water quality · Maintain habitat connectivity · Increase zone of flood tolerant vegetation, by drowning out encroaching terrestrial species · Provide flows for spawning and migration of priority fish species		· Improve access to suitable habitat for priority fauna · Maintain habitat connectivity · Increase zone of flood tolerant vegetation, by drowning out encroaching terrestrial species · Provide flows for spawning and migration of priority fish species · Maintain channel geomorphology	
Water volume to be delivered	1000 ML		1000 - 1500 ML		1500 - 2700 ML		0 - 3500 ML	
Additional watering actions that may be delivered if more environmental water was allocated	1. Autumn high to trigger downstream spawning migration of Australian Grayling (Apr/May, 1 event required 2 in 3 years, priority) 2. Winter / spring fresh for fish migration / vegetation (Jun/Jul, 1 event)		3. Winter / spring fresh for vegetation/fish migration (Jun-Sep, 1 event)		4. Winter / spring high to discourage terrestrial vegetation (Sep/Oct, 1 event)		N/A	

1.2.7 Flow management tools

Melbourne Water currently utilise a number of documents and spreadsheets that assist in decision making regarding the managed use of the Environmental Entitlement and delivery of environmental flows to Lower Tarago (Reach 2) and Lower Bunyip (Reach 6) under varying climatic scenarios. Existing documents and spreadsheets have been developed with reference to earlier objectives and flow recommendations.

In light of the revisions to environmental flow objectives and recommendations, Melbourne Water have identified the need to develop a robust scenario planning management framework to help in the management of the Environmental Entitlement and delivery of environmental flows. The framework is to consider: how watering actions should shift in different climatic scenarios (very dry, dry, average and wet), the water requirements for each scenario and available entitlement based on 10.3% of inflows.

It is recommended that the scenario planning management framework and information requirements identified above are developed further and consolidated in a Scenario Planning and Flow Management Tool. It is expected that this tool will achieve a number of purposes and requirements:

- Informative – Updated analysis of volumes to meet flow recommendations, compliance and short falls for different climatic scenarios (very dry, dry, average and wet).
- Analytical – Provide summary reports on achievement of environmental flows against that documented in seasonal watering proposal (i.e. achievement of flow recommendations, volume of water used, amount remaining in environmental entitlement).
- Predictive – Forecasts of future streamflows to assist with ongoing management of environmental entitlement and decisions regarding timing, magnitude and duration of environmental flow releases.

1.2.8 Other recommendations

1.2.8.1 Monitoring and investigations

The following recommendations are made to assist in monitoring the environmental condition of the waterways and ecological responses to flows:

- Further monitoring of fish movements with flows, in particular Australian Grayling spawning and migration with Autumn high and Winter / Spring freshes in the Lower Tarago (Reach 2) and Lower Bunyip (Reach 6).
- Monitoring of instream physical habitat, in particular scour holes around large wood and pools, their response to scouring flows (freshes / high flows) and the time it takes between scour events for these areas to fill in with sediments.
- Surveys of the types of vegetation present in the various reaches and their condition, to help clarify vegetation objectives and specific investigations into the effectiveness of episodic high flows in preventing terrestrialisation on in-stream environments.

In contrast to the number of recent investigations on fish monitoring and on platypus surveys, there is little quantitative data on the vegetation of the Tarago/Bunyip system. EVC mapping provides some useful background to the types of vegetation present in the riparian zone, but the available map sets are coarse and are inadequate for in-stream vegetation and the tall emergent vegetation that can fringes the streamside. Both may be important components of the aquatic vegetation. Reach-specific surveys are required to fill this generic knowledge gap. Specific investigations need to be carried out to determine whether the recommended regime of permanent low flows and episodic high flows (especially in winter/autumn) is adequate in preventing terrestrialisation of in-stream habitats.

1.2.8.2 Complementary management actions

The technical panel have had some difficulty in formulating complementary actions as these almost always require a field inspection to inspect the reaches.

Sections of waterways may benefit from fencing, stock removal, and if possible limiting browsing by feral animals, and revegetation with species appropriate for the EVC and removal of levees that interfere with overbank inundation. Selected reintroduction of large wood into the channel may also assist with the rehabilitation of channel form and habitat.

A number of complementary management actions were identified to support the objective of maintaining/improving the current status of platypus populations:

- Modification of Tarago Weir to allow passage and reconnect platypus populations in the upper and lower Tarago River.
- Education to increase public awareness of impacts of litter, discarded fishing equipment and enclosed yabby traps on platypus.
- Rehabilitation of the riparian zone by excluding stock, removing weeds (particularly willows) and revegetate with native species.

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Appendix A. Ecological objectives

Table A.1 : Reach 1 – Upper Tarago objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing channel form and habitat	G1-1	Maintain coarse bed sediments and remove silt from timber	Low flow	All year	· Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G1-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	· Formation and maintenance of scour holes around large wood	Short	
		G1-3	Maintain channel form and scour pools	Freshes	Winter / spring	· Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates	M1-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain wide diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates and yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M1-2		Low flow	Winter / spring			
		M1-3	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M1-4		Fresh	Winter / spring			
		M1-5	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year.
		M1-6		Bankfull	Winter / spring			
Fish	Maintain or improve populations of native fish (river blackfish, ornate galaxias and broad-finned galaxias).	F1-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow	All year	· Maintenance of hydraulic habitat; localised movements	Short to medium	Revised list of fish species documented in objective from EarthTech (2006c). Added ornate galaxias and broad-finned galaxias. Removed short-finned eels, given the presence of Tarago Reservoir as a barrier (even though some eels can get past). Similar logic could apply also to broad-finned galaxias, although they can form land-locked populations (McDowall 2000), which makes this upper reach a potential area for self-sustaining populations.
				Fresh	Throughout year			

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		F1-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	Fresh	Winter / spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective.
		F1-3	Inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae	Fresh	Autumn	· Spawning and downstream transport of larvae	Short	New fish objective. Broad-finned galaxias spawn in inundated riparian areas on the stream margins in autumn. Hatching and downstream drift of larvae occurs when eggs are disturbed by a subsequent flow (O'Connor & Koehn 1998).
Vegetation	Maintain high quality instream, fringing and riparian vegetation	V1-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer / autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. It is not clear whether there is any instream vegetation to maintain in Reach 1. The MW Vision and EWMP environmental objectives (Melbourne Water & Jacobs 2017) refer only to maintaining high-quality vegetation in the upper catchment of the Tarago. We have assumed there is some instream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped riparian zone of EVC 18, but vegetation surveys as recommended in Section 1.2.7 are required to test this assumption.
		V1-2		Low flow	Winter / spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	
		V1-3	Maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation Prevent encroachment of terrestrial vegetation onto instream bars	Fresh	Summer / autumn	· Wet lower benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V1-4		Fresh	Winter / spring	· Wet higher benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		V1-5	Maintain riparian vegetation (e.g. EVC 18 Riparian Forest)	Bankfull	Winter / spring	· Inundate higher benches and banks to maintain riparian vegetation · Inundate higher benches and banks to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to Long	
		V1-6		Overbank	Winter / spring	· Inundate floodplain to maintain riparian/floodplain vegetation · Inundate floodplain to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to Long	
Platypus	Maintain/improve current status of population	P1-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low flow	All year	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).
		P1-2	Maintain refuge pools >1m depth.	Low flow (extreme)	Extended dry periods (drought)	· Maintain refuge areas during drought.	Short to medium	
		P1-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance.	Freshes	All year	· Improve habitat quality and food resources for platypuses.	Short to medium	
		P1-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	· Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P1-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	· Improve reproductive success.	Short	
Birds, Frogs and Amenity		BFA1-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provides disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provides a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species Amenity - Maintain and/or improve condition	BFA1-2		Freshes	Summer / autumn	· Provides disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provides a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provides flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provides a variety of habitats.	Short to medium	
		BFA1-3	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA1-4		Fresh	Winter / spring	· Provides flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provides a variety of habitats for birds · Entrains and transports terrestrial organic matter along that has accumulated on benches.	Short to medium	
		BFA1-5	Maintain instream habitats and improve the condition of billabongs connected around bankfull	Bankfull	Winter / spring	· Increase habitat area, including access to large woody debris and overhanging banks for instream biota, and engage floodplain and billabong habitat for frogs and waterbirds · Helps to disturb and reset aquatic and riparian vegetation communities, important for a range of diverse habitat types for birds and frogs	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		BFA1-6	Reconnect the floodplain and floodplain billabongs with the instream channel Maintain wetland/billabong species and communities	Overbank	Winter / spring	· Improves the frequency and extent of flooding in floodplain wetlands and billabongs. · Provides water for flood-tolerant vegetation such as River Red Gum · Provides wetted habitat for waterbird and frog species who don't necessarily require instream habitat	Short to medium	

Table A.2 : Reach 2 – Lower Tarago objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Rehabilitate channel form and habitat	G2-1	Maintain coarse bed sediments and remove fine silt from timber	Low flow	All year	· Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G2-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	· Formation and maintenance of scour holes around large wood	Short	
		G2-3	Maintain channel form and scour pools	High flow	Winter / spring	· Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates	M2-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M2-2		Low flow	Winter / spring			
		M2-3	Maintain oxygenated conditions during low flow periods	Fresh	Summer / autumn	· Re-oxygenation of water if low flow period results in reduced dissolved oxygen concentrations	Short	This is not exclusive to macroinvertebrates, is also relevant to fish.
		M2-4	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M2-5		Fresh	Winter / spring		Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M2-6	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year
Fish	Maintain or improve populations of native fish (river blackfish, ornate galaxias,	F2-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow	All year	· Maintenance of hydraulic habitat; Localised movements	Short to medium	Rewritten objectives so that they are more explicit as to which flow components are important and their function for fish, with reference to migratory and non-migratory species.
				Freshes	Throughout year			

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
	Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias).	F2-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	Freshes / High flow	Winter / spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective
		F2-3	Facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias) fishes from downstream river reaches	Freshes / High flow	Spring / early summer	· Upstream immigration from downstream river reaches	Short	Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F2-4	Cue downstream spawning migration by Australian grayling to lower river reaches	High flow	Autumn	· Downstream migration to lower river reaches to spawn	Short	Revised wording of objective and timing of high flow. Australian grayling undertakes downstream migrations to spawn between late March and May (Koster et al. 2017, Koster et al. 2013).
		F2-5	Cue downstream migration by tupong to the sea to spawn	Freshes / High flow	Late Autumn / winter	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by tupong. Tupong undertake downstream migrations between late May and August, associated with high river flows (Crook et al. 2010).
		F2-6	Cue downstream migration by eels to the sea to spawn	Freshes / High flow	Throughout year, especially late Summer	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain or improve existing instream, fringing and riparian vegetation Discourage terrestrialisation of the channel	V2-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer / autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. It is not clear whether there is any instream vegetation to maintain in Reach 2. We have assumed there is some instream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped riparian zone of EVC 18, but vegetation surveys are required to test this assumption. Note that the earlier flows assessment (EarthTech 2007) cited a need for Overbank flows in Reach 2, so that flow component is included within Objective V2-7. This has also been the approach for the other reaches, where the earlier report has included a requirement for Overbank flows, as it is assumed this is based on their 2006 field inspection. The MW Vision and EWMP environmental objectives (Melbourne Water & Jacobs 2017) refer only to preventing further declines in the lower catchment of the Tarago and stress discouraging terrestrial colonisation of the channel.
		V2-2		Low flow	Winter / spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	
		V2-3	Maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation	Fresh	Summer / autumn	· Wet lower benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation	Short to Medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
						· Facilitate dispersion of propagules		
		V2-4		Fresh	Winter / spring	· Wet higher benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V2-5	Prevent encroachment of terrestrial vegetation onto instream bars	High	Summer / autumn	· Inundate lower benches to inhibit colonization by terrestrial species	Short to Medium	
		V2-6	Provide deeper, permanently inundated in-stream environments over winter/spring Promote inundation-tolerant aquatic or riparian vegetation and inhibit inundation-intolerant riparian or terrestrial vegetation Transport plant propagules and plant detritus downstream Provide hydrological complexity (and therefore vegetation zonation)	High flow	Winter / spring	· Maintain in-stream and riparian vegetation characteristics such as species richness and abundance, structural complexity, vertical zonation & spatial extent	Short to medium	
		V2-7	Maintain riparian vegetation (e.g. EVC 18 Riparian Forest)	Bankfull	Winter / spring	· Inundate higher benches and banks to maintain riparian vegetation · Inundate higher benches and banks to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to Long	
		V2-8		Overbank	Winter / spring	· Inundate floodplain to maintain riparian/floodplain vegetation · Inundate floodplain to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to Long	
Platypus	Maintain/improve current status of population	P2-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	All year	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).
		P2-2	Maintain refuge pools >1m depth.	Low Flow (extreme)	Extended dry periods (drought)	· Maintain refuge areas during drought.	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		P2-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance.	Freshes	All year	· Improve habitat quality and food resources for platypuses.	Short to medium	
		P2-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	· Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P2-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	· Improve reproductive success.	Short	
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species Amenity - Maintain and/or improve condition	BFA2-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provides disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provides a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.
		BFA2-2		Freshes	Summer / autumn	· Provides disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provides a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provides flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provides a variety of habitats.	Short to medium	
		BFA2-3	Rehabilitate and maintain habitat within the higher parts of the river channel	High flow	Summer / autumn	· Moves sediment along the river improving the quality of, and access to, instream habitat · Sustains longitudinal connectivity, providing opportunities to move along and between habitats for waterbirds. · Helps to influence vegetation zonation patterns across the channel, which provides a variety of habitats.	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		BFA2-4	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA2-5		Fresh	Winter / spring	· Provides flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provides a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated on benches.	Short to medium	
		BFA2-6	Maintain instream habitats and improve the condition of billabongs connected around bankfull	Bankfull	Winter / spring	· Increase habitat area, including access to large woody debris and overhanging banks for instream biota, and engage floodplain and billabong habitat for frogs and waterbirds · Helps to disturb and reset aquatic and riparian vegetation communities, important for a range of diverse habitat types for birds and frogs	Short to medium	
		BFA2-7	Reconnect the floodplain and floodplain billabongs with the instream channel Maintain wetland/billabong species and communities	Overbank	Winter / spring	· Improves the frequency and extent of flooding in floodplain wetlands and billabongs. · Provides water for flood-tolerant vegetation such as River Red Gum · Provides wetted habitat for waterbird and frog species who don't necessarily require instream habitat	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Rehabilitate channel form and habitat	G2-1	Maintain coarse bed sediments and remove fine silt from timber	Low flow	All year	Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	
		G2-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	Formation and maintenance of scour holes around large wood	Short	
		G2-3	Maintain channel form and scour pools	High flow	Winter / spring	Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates	M2-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M2-2		Low flow	Winter / spring			
		M2-3	Maintain oxygenated conditions during low flow periods	Fresh	Summer / autumn	· Re-oxygenation of water if low flow period results in reduced dissolved oxygen concentrations	Short	This is not exclusive to macroinvertebrates, is also relevant to fish.
		M2-4	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M2-5		Fresh	Winter / spring		Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M2-6	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year

Table A.3 : Reach 3 - Labertouche Creek objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing channel form and habitat	G3-1	Maintain coarse bed sediments and remove silt from timber	Low flow	All year	· Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G3-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	· Formation and maintenance of scour holes around large wood	Short	
		G3-3	Maintain channel form and scour pools	High flow	Anytime	· Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates, especially burrowing crayfish	M3-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types (including burrowing crayfish). Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates and yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M3-2		Low flow	Winter / spring			
		M3-3	Maintain oxygenated conditions during low flow periods	Fresh	Summer / autumn	· Re-oxygenation of water if low flow period results in reduced dissolved oxygen concentrations	Short	This is not exclusive to macroinvertebrates, is also relevant to fish.
		M3-4	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M3-5		Fresh	Winter / spring			
		M3-6	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year
		M3-7		Overbank	Winter / spring			

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Fish	Maintain or improve populations of native fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, and common galaxias).	F3-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow Freshes	All year Throughout year	· Maintenance of hydraulic habitat; Localised movements	Short to medium	Rewritten objectives so that they are more explicit as to which flow components are important and their function for fish, with reference to migratory and non-migratory species. No records of dwarf galaxias, but could occur in this reach.
		F3-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	Freshes / High flow	Winter / Spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective
		F3-3	Inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae to the sea	Fresh	Autumn	· Spawning and downstream transport of larvae to the sea	Short	New fish objective. Broad-finned galaxias spawn in inundated riparian areas on the stream margins in autumn. Hatching and downstream drift of larvae occurs when eggs are disturbed by a subsequent flow (O'Connor & Koehn 1998).
		F3-4	Facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) from downstream river reaches	Freshes	Spring / Early Summer	· Upstream immigration from downstream river reaches	Short	Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F3-5	Cue downstream migration by eels to the sea to spawn	Freshes / High flow	Throughout year, especially late Summer	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain or improve existing instream, fringing and riparian vegetation	V3-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer/Autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. As per the two previous Reaches, we are not sure whether there is any instream vegetation to maintain in Reach 3 but we have assumed there is some instream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped of riparian zone of EVC 18 and EVC 83. As for earlier reaches, vegetation surveys are required to test this assumption. There seem to be no environmental objectives in the MW Vision and EWMP environmental objectives (Melbourne Water & Jacobs 2017) for Labertouche Ck. The major riparian EVC along the streamside in the lower parts of the Creek is EVC 83 Swampy Riparian Woodland, which is rated as Endangered in this bioregion.
		V3-2		Low flow	Winter/Spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		V3-3	Maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation	Fresh	Summer/Autumn	· Wet lower benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V3-4		Fresh	Winter/Spring	· Wet higher benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V3-5	Prevent encroachment of terrestrial vegetation onto instream bars	Fresh	Summer/Autumn	· Inundate lower benches to inhibit colonization by terrestrial species	Short to Medium	
		V3-6	Provide deeper, permanently inundated in-stream environments over winter/spring Promote inundation-tolerant aquatic or riparian vegetation and inhibit inundation-intolerant riparian or terrestrial vegetation Transport plant propagules and plant detritus downstream Provide hydrological complexity (and therefore vegetation zonation)	High flow	Winter / spring	· Maintain in-stream and riparian vegetation characteristics such as species richness and abundance, structural complexity, vertical zonation & spatial extent	Short to medium	
		V3-7	Maintain riparian vegetation (e.g. EVC 18 Riparian Forest and especially the Endangered EVC 83 Swampy Riparian Woodland)	Bankfull	Winter/Spring	· Inundate higher benches and banks to maintain riparian vegetation · Inundate higher benches and banks to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	
		V3-8		Overbank	Winter/Spring	· Inundate floodplain to maintain riparian/floodplain vegetation · Inundate floodplain to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	
Platypus	Maintain/improve current status of population	P3-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	All year	Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		P3-2	Maintain refuge pools >1m depth.	Low Flow (extreme)	Extended dry periods (drought)	Maintain refuge areas during drought.	Short to medium	
		P3-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance, improve water quality.	Freshes	All year	Improve habitat quality and food resources for platypuses.	Short to medium	
		P3-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P3-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	Improve reproductive success.	Short	
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species	BFA3-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provide disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provide a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.
	Amenity - Maintain and/or improve condition	BFA3-2		Freshes	Summer / autumn	· Provide disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provide a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provide flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provide a variety of habitats.	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		BFA3-3	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA3-4		Fresh	Winter / spring	· Provide flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provide a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated on benches.	Short to medium	
		BFA3-5	Maintain instream habitats and improve the condition of billabongs connected around bankfull	Bankfull	Winter / spring	· Increase habitat area, including access to large woody debris and overhanging banks for instream biota, and engage floodplain and billabong habitat for frogs and waterbirds · Helps to disturb and reset aquatic and riparian vegetation communities, important for a range of diverse habitat types for birds and frogs	Short to medium	
		BFA3-6	Reconnect the floodplain and floodplain billabongs with the instream channel Maintain wetland/billabong species and communities	Overbank	Winter / spring	· Improves the frequency and extent of flooding in floodplain wetlands and billabongs. · Provide water for flood-tolerant vegetation such as River Red Gum · Provide wetted habitat for waterbird and frog species who don't necessarily require instream habitat	Short to medium	

Table A.4 : Reach 4 – Upper Bunyip River objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing channel form and habitat	G4-1	Maintain coarse bed sediments and remove silt from timber	Low flow	All year	· Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G4-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	· Formation and maintenance of scour holes around large wood	Short	
		G4-3	Maintain channel form and scour pools	High flow	Anytime	· Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates	M4-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates and yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M4-2		Low flow	Winter / spring			
		M4-3	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (eg submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M4-4		Fresh	Winter / spring			
		M4-5	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year. Not sure there is overbank flows in this reach – it's pretty confined
		M4-6		Bankfull	Winter / spring			
Fish	Maintain or improve populations of native fish (river blackfish, ornate galaxias, southern pygmy perch, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong,	F4-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow	All year	· Maintenance of hydraulic habitat; Localised movements	Short to medium	Rewritten objectives so that they are more explicit as to which flow components are important and their function for fish, with reference to migratory and non-migratory species.
				Freshes	Throughout year			
		F4-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	Freshes / High flow	Winter / spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective
		F4-3	Facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) and amphidromous	Freshes / High flow	Spring / early summer	· Upstream immigration from downstream river reaches	Short	Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
	broad-finned galaxias, spotted galaxias, and common galaxias).		(Australian grayling, broad-finned galaxias, spotted galaxias) fishes from downstream river reaches					broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F4-4	Cue downstream spawning migration by Australian grayling to lower river reaches	High	Autumn	· Downstream migration to lower river reaches to spawn	Short	Revised wording of objective and timing of high flow. Australian grayling undertakes downstream migrations to spawn between late March and May (Koster et al. 2017, Koster et al. 2013).
		F4-5	Inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae to the sea	Freshes	Autumn	· Spawning and downstream transport of larvae to the sea	Short	New fish objective. Broad-finned galaxias spawn in inundated riparian areas on the stream margins in autumn. Hatching and downstream drift of larvae occurs when eggs are disturbed by a subsequent flow (O'Connor & Koehn 1998).
		F4-6	Cue downstream migration by tupong to the sea to spawn	Freshes / High flow	Late Autumn / winter	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by tupong. Tupong undertake downstream migrations between late May and August, associated with high river flows (Crook et al. 2010).
		F4-7	Cue downstream migration by eels to the sea to spawn	Freshes / High flow	Throughout year, especially late summer	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain high-quality or improve existing lower-quality instream, fringing and riparian vegetation	V4-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer / autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. As per the three previous Reaches, it is unclear whether there is any instream vegetation to maintain in Reach 4. We have assumed there is some instream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped of riparian zone of EVC 18. and EVC 83. 3) but as before vegetation surveys are required to test this assumption. There seem to be no environmental objectives in the MW Vision and EWMP environmental objectives (Melbourne Water & Jacobs 2017) for the upper Bunyip River other than the ambiguous 'maintain high-quality vegetation in the upper catchment'. The major riparian EVC along the streamside in the lower parts of Diamond Creek is EVC 83 Swampy Riparian Woodland, which is Endangered in this bioregion. Otherwise, the main riparian vegetation is EVC 18 Riparian Forest, which is ranked Of Least Concern in this bioregion.
		V4-2		Low flow	Winter / spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	
		V4-3		Fresh	Summer / autumn	· Wet lower benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation	Short to Medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
			Maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation Prevent encroachment of terrestrial vegetation onto instream bars			· Facilitate dispersion of propagules		
		V4-4		Fresh	Winter / spring	· Wet higher benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V4-5	Prevent encroachment of terrestrial vegetation onto instream bars	High	Summer/Autumn	· Inundate lower benches to inhibit colonization by terrestrial species	Short to Medium	
		V4-6	Provide deeper, permanently inundated in-stream environments over winter/spring Promote inundation-tolerant aquatic or riparian vegetation and inhibit inundation-intolerant riparian or terrestrial vegetation Transport plant propagules and plant detritus downstream Provide hydrological complexity (and therefore vegetation zonation)	High flow	Winter / spring	· Maintain in-stream and riparian vegetation characteristics such as species richness and abundance, structural complexity, vertical zonation & spatial extent	Short to medium	
		V4-7	Maintain riparian vegetation (including the EVC 18 Riparian Forest and the Endangered EVC 83 Swampy Riparian Woodland along the lowest sections of Diamond Creek and the middle-lower sections of Reach 4 of the Bunyip River)	Bankfull	Winter / spring	· Inundate higher benches and banks to maintain riparian vegetation · Inundate higher benches and banks to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	
		V4-8	Maintain riparian and floodplain vegetation (e.g. EVC 18 Riparian Forest and EVC 83 Swampy Riparian Woodland)	Overbank	Winter / spring	· Inundate floodplain to maintain riparian/floodplain vegetation · Inundate floodplain to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	
Platypus	Maintain/improve current status of population	P4-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	All year	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).
		P4-2	Maintain refuge pools >1m depth.	Low Flow (extreme)	Extended dry periods (drought)	· Maintain refuge areas during drought.	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		P4-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance, improve water quality.	Freshes	All year	· Improve habitat quality and food resources for platypuses.	Short to medium	
		P4-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	· Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P4-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	· Improve reproductive success.	Short	
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species Amenity - Maintain and/or improve condition	BFA4-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provide disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provide a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.
		BFA4-2		Freshes	Summer / autumn	· Provide disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provide a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provide flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provide a variety of habitats.	Short to medium	
		BFA4-3	Rehabilitate and maintain habitat within the higher parts of the river channel	High flow	Summer / autumn	· Moves sediment along the river improving the quality of, and access to, instream habitat · Sustains longitudinal connectivity, providing opportunities to move along and between habitats for waterbirds. · Helps to influence vegetation zonation patterns across the	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
						channel, which provides a variety of habitats.		
		BFA4-4	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA4-5		Fresh	Winter / spring	· Provide flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provide a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated on benches.	Short to medium	
		BFA4-6	Maintain instream habitats and improve the condition of billabongs connected around bankfull	Bankfull	Winter / spring	· Increase habitat area, including access to large woody debris and overhanging banks for instream biota, and engage floodplain and billabong habitat for frogs and waterbirds · Helps to disturb and reset aquatic and riparian vegetation communities, important for a range of diverse habitat types for birds and frogs	Short to medium	
		BFA4-7	Reconnect the floodplain and floodplain billabongs with the instream channel Maintain wetland/billabong species and communities	Overbank	Winter / spring	· Improves the frequency and extent of flooding in floodplain wetlands and billabongs. · Provide water for flood-tolerant vegetation such as River Red Gum · Provide wetted habitat for waterbird and frog species who don't necessarily require instream habitat	Short to medium	

Table A.5 : Reach 5 – Cannibal Creek objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing channel form and habitat	G5-1	Maintain coarse bed sediments and remove silt from timber	Low flow	All year	· Maintain substrate conditions, limit accumulation of fine sediments and excessive development of biofilms on woody debris	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G5-2	Scour hole formation and maintenance around large wood	Freshes	Throughout year	· Formation and maintenance of scour holes around large wood	Short	
		G5-3	Maintain channel form and scour pools	High flow	Anytime	· Maintain channel features	Medium to long	
				Bankfull	Anytime			
Macroinvertebrates and water quality	Maintain high diversity, abundance and biomass of macroinvertebrates	M5-1	Bed habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates and yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of 'Expected response' to clarify why seasonal differences in low flow are required
		M5-2	Bed habitat availability	Low flow	Winter / spring			
		M5-3	Habitat maintenance – periodic scour of bed to maintain quality of riffle and pool habitat	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and gravels to maintain and create a diversity of riffle habitats	Short	Revised wording of objective and related 'Functions' and 'Expected response'
		M5-4		Fresh	Winter / spring			
		M5-5	Entrain terrestrial carbon to the stream	Fresh	Winter / spring	· Provision of terrestrial organic matter as a food source for microbial communities and some macroinvertebrate species; contributes to overall food resource to support macroinvertebrates, fish and platypus.	Short	Revised wording of 'Expected response'. Differences in flow magnitudes reflect variation in stream flow and frequency of different sized events. I.e. bankfull might not occur every year. Not sure what the overbank flow need is, but there are some wetlands and floodrunners.
		M5-6		Bankfull / overbank	Winter / spring			

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Fish	Maintain or improve populations of native fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong and broad-finned galaxias), focusing on protecting populations of dwarf galaxias	F5-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow Freshes	All year Throughout year	· Maintenance of hydraulic habitat; Localised movements	Short to medium	Rewritten objectives so that they are more explicit as to which flow components are important and their function for fish, with reference to migratory and non-migratory species. River blackfish now vary rare in this reach.
		F5-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	High flow	Winter / spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective
		F5-3	Inundate low-lying swamps for breeding of dwarf galaxias	Freshes	Winter / spring	· Breeding of dwarf galaxias		New fish objective specific for dwarf galaxias
		F5-4	Maintain natural wetting and drying cycle regimes	Low flow	Summer / autumn	· Survival of dwarf galaxias		New fish objective. Periodic drying provide a way of protecting dwarf galaxias in water bodies where eastern gambusia has invaded (Coleman et al. 2016)
		F5-5	Inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae to the sea	Freshes	Autumn	· Spawning and downstream transport of larvae to the sea	Short	New fish objective. Broad-finned galaxias spawn in inundated riparian areas on the stream margins in autumn. Hatching and downstream drift of larvae occurs when eggs are disturbed by a subsequent flow (O'Connor & Koehn 1998).
		F5-6	Facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) and amphidromous (broad-finned galaxias) fishes from downstream river reaches.	High flow	Spring / early summer	· Upstream immigration from downstream river reaches	Short	Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F5-7	Cue downstream migration by eels to the sea to spawn	Freshes	Throughout year, especially late summer	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain high-quality or improve existing lower-quality instream, fringing and riparian vegetation	V5-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer / autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. As per the previous Reaches, we are not sure whether there is any instream vegetation to maintain in Reach 5. We have assumed there is some instream vegetation (e.g. Water Ribbons) and fringing vegetation (e.g. reeds, rushes) as well as the well-mapped of

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		V5-2		Low flow	Winter / spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	riparian zone of EVC 18. Vegetation surveys are required to test this assumption. There seem to be no environmental objectives in the MW Vision and EWMP environmental objectives (Melbourne Water & Jacobs 2017) for Cannibal Creek other than the ambiguous 'maintain high-quality vegetation in the upper catchment'. The only riparian EVC along the streamside according the EVC mapping is EVC 18 Riparian Forest, which is ranked Of Least Concern in this bioregion.
		V5-3	Maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation	Fresh	Summer / autumn	· Wet lower benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V5-4		Fresh	Winter / spring	· Wet higher benches to maintain fringing aquatic vegetation and ensure vertical zonation of fringing vegetation · Facilitate dispersion of propagules	Short to Medium	
		V5-5	Prevent encroachment of terrestrial vegetation onto instream bars	Fresh	Summer / autumn	· Inundate lower benches to inhibit colonization by terrestrial species	Short to Medium	
		V5-6	Maintain riparian vegetation (e.g. EVC 18 Riparian Forest and especially the Endangered EVC 83 Swampy Riparian Woodland)	Bankfull	Winter / spring	· Inundate higher benches and banks to maintain riparian vegetation · Inundate higher benches and banks to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	
		V5-7		Overbank	Winter / spring	· Inundate floodplain to maintain riparian/floodplain vegetation · Inundate floodplain to facilitate sexual recruitment · Facilitate dispersion of propagules · Provide major hydrological disturbance	Medium to long	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Platypus	Maintain/improve current status of population	P5-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	Summer / autumn	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).
		P5-2	Maintain refuge pools >1m depth.	Low Flow (extreme)	Extended dry periods (drought)	· Maintain refuge areas during drought.	Short to medium	
		P5-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance, improve water quality.	Freshes	All year	· Improve habitat quality and food resources for platypuses.	Short to medium	
		P5-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	· Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P5-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	· Improve reproductive success.	Short	
		P5-6	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	Summer / autumn	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and	BFA5-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provide disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provide a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
	distribution of expected species Amenity - Maintain and/or improve condition	BFA5-2		Freshes	Summer / autumn	· Provide disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provide a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provide flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provide a variety of habitats.	Short to medium	
		BFA5-3	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA5-4		Fresh	Winter / spring	· Provide flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provide a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated on benches.	Short to medium	
		BFA5-5	Maintain instream habitats and improve the condition of billabongs connected around bankfull	Bankfull	Winter / spring	· Increase habitat area, including access to large woody debris and overhanging banks for instream biota, and engage floodplain and billabong habitat for frogs and waterbirds · Helps to disturb and reset aquatic and riparian vegetation communities, important for a range of diverse habitat types for birds and frogs	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		BFA5-6	Reconnect the floodplain and floodplain billabongs with the instream channel Maintain wetland/billabong species and communities	Overbank	Winter / spring	· Improves the frequency and extent of flooding in floodplain wetlands and billabongs. · Provide water for flood-tolerant vegetation such as River Red Gum · Provide wetted habitat for waterbird and frog species who don't necessarily require instream habitat	Short to medium	

Table A.6 : Reach 6 –Lower Bunyip / Bunyip Main Drain objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing channel form and habitat	G6-1	Maintain sandy substrates and prevent siltation	Low flow	All year	· Maintain substrate conditions and limit accumulation of fine sediments	Short	Revised wording and consolidated geomorphology (physical form) objectives documented in EarthTech (2006b)
		G6-2	Maintain channel form and scour pools behind drop structures	High flow	Winter / spring	· Maintain channel features and depth in pools	Medium to long	
				Channel maintenance	Anytime			
	Prevent gross channel change	G6-3	Prevent bed and bank erosion and protect existing substrates Limit frequency and duration of flows above scouring thresholds	Freshes / High flows	Throughout year	· Rate of rise/fall managed to minimise bank erosion/failure · Prevent any further increase in the frequency of flows above scouring thresholds	Short	
Macroinvertebrates and water quality	Maintain excellent condition macroinvertebrate community	M6-1	Edge habitat availability	Low flow	Summer / autumn	· Provision of habitat to sustain a diversity of macroinvertebrate types. Requires seasonal variation in summer/autumn and winter/spring low flows to inundate additional habitat area in winter/spring to account for lower metabolic rates and yet maintain biomass production, especially to provide a sustained food resource for platypus	Short to medium	Revised wording of objective to clarify that we want to achieve high diversity, abundance and biomass of macroinvertebrates. Revised wording of ‘Expected response’ to clarify why seasonal differences in low flow are required
		M6-2		Low flow	Winter / spring			
		M6-3	Habitat maintenance	Fresh	Summer / autumn	· Removal of sediments and biofilm from woody debris to enhance value of instream habitat (e.g. submerged logs) · Disturbance of sands and to maintain and create a diversity of riffle / shallow habitats (where present)	Short	Revised wording of objective and related ‘Functions’ and ‘Expected response’
		M6-4		Fresh	Winter / spring			
		M6-5	Maintain oxygenated conditions during low flow periods	Fresh	Summer / autumn	· Re-oxygenation of water if low flow period results in reduced dissolved oxygen concentrations	Short	This is not exclusive to macroinvertebrates, is also relevant to fish.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Fish	Maintain or improve populations of native fish (river blackfish, ornate galaxias, southern pygmy perch, dwarf galaxias, Australian grayling, short-finned eel, long-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, common galaxias, and Australian mudfish).	F6-1	Maintain hydraulic habitat (i.e. pool, riffle, run) and passage for local movement	Low flow Freshes	All year Throughout year	· Maintenance of hydraulic habitat; Localised movements	Short to medium	Rewritten objectives so that they are more explicit as to which flow components are important and their function for fish, with reference to migratory and non-migratory species.
		F6-2	Flush accumulated fine sediments to maintain or improve quality and availability of habitats	Freshes / High flow	Winter / spring	· Accumulated fine sediments scoured from the river bed	Short to medium	New fish objective
		F6-3	Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from downstream river reaches.	Freshes / High flow	Spring / early summer	· Upstream immigration from downstream river reaches	Short	Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F6-4	Cue downstream spawning migration by Australian grayling to lower river reaches.	High	Autumn	· Downstream migration to lower river reaches to spawn	Short	Revised wording of objective and timing of high flow. Australian grayling undertakes downstream migrations to spawn between late March and May (Koster et al. 2017, Koster et al. 2013).
		F6-5	Cue downstream migration by tupong to the sea to spawn.	Freshes / High flow	Late Autumn / winter	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by tupong. Tupong undertake downstream migrations between late May and August, associated with high river flows (Crook et al. 2010).
		F6-6	Cue downstream migration by eels to the sea to spawn	Freshes / High flow	Throughout year, especially late Summer	· Downstream migration to the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain existing instream and fringing vegetation	V6-1	Maintain instream and fringing aquatic vegetation and prevent encroachment of terrestrial vegetation into instream zone	Low flow	Summer / autumn	· Provide permanent water for instream species such as Water Ribbons and for fringing reeds, rushes and sedges · Prolonged inundation of instream channel areas to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	Restructured and revised objectives and related 'Functions' and 'Expected response' to reflect different vegetation components/habitats and watering requirements. The original Earth Tech report provided flows only for instream vegetation in Reach 6. We have checked the most recent EVC mapping for the reach and it seems there is no riparian vegetation along the Bunyip River below the confluence with the Tarago (i.e. in our Reach 6, along the Lower Bunyip / Bunyip Main Drain). This is probably why there are not environmental objectives for anything other than instream vegetation for this Reach. On this basis, we similarly have not set environmental objectives for other vegetation components in this reach. Vegetation surveys, as recommended in Section 1.2.7, are required to test this assumption.
		V6-2		Low flow	Winter / spring	· Wet the full width of the channel · Inundate low-level benches (via elevated Winter/Spring low flow) to ensure vertical zonation of fringing vegetation · Prolonged inundation of instream channel, lower bench and bars to disadvantage terrestrial species and prevent their colonizing of instream channel	Short to Medium	

Platypus	Maintain/improve current status of population	P6-1	Maintain platypus habitat, maintain longitudinal connectivity across riffle areas, minimise predation risk, allow juvenile dispersal, support macroinvertebrate populations.	Low Flow	Summer / autumn	· Provision of habitat for platypuses and macroinvertebrate food resources.	Short to medium	New objectives developed for Platypus, drawing upon insights from platypus surveys and conceptual models of platypus flow requirements (Jacobs et al. 2016a).
		P6-2	Maintain refuge pools >1m depth.	Low Flow (extreme)	Extended dry periods (drought)	· Maintain refuge areas during drought.	Short to medium	
		P6-3	Promote habitat diversity, scour fine sediment, promote macroinvertebrate diversity/abundance, improve water quality.	Freshes	All year	· Improve habitat quality and food resources for platypuses.	Short to medium	
		P6-4	Minimise bank erosion and in-stream sedimentation	Limit flows above scouring thresholds	All year	· Improve habitat quality for platypus food resources (macroinvertebrates)	Medium	
		P6-5	Prevent inundation of breeding burrows	Avoid bankfull or overbank flows	Nov-Feb	· Improve reproductive success.	Short	
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species Amenity - Maintain and/or improve condition	BFA6-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain permanent pools with an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provide disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provide a suitable range of depths for the growth of in-stream vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.
		BFA6-2		Freshes	Summer / autumn	· Provide disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provide a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provide flow variability to maintain a diversity of emergent and riparian vegetation and helps to influence vegetation zonation patterns across the channel, which then provide a variety of habitats.	Short to medium	

		BFA6-3	Rehabilitate and maintain habitat within the higher parts of the river channel	High flow	Summer / autumn	· Moves sediment along the river improving the quality of, and access to, instream habitat · Sustains longitudinal connectivity, providing opportunities to move along and between habitats for waterbirds. · Helps to influence vegetation zonation patterns across the channel, which provide a variety of habitats.	Short to medium	
		BFA6-4	Maintain access to good quality physical habitat, provide good water quality, and support the growth of instream vegetation, an important source of food resources and habitat	Low flow	Winter / spring	· Increase habitat area for instream flora and fauna including access to large woody debris and overhanging banks. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA6-5		Fresh	Winter / spring	· Provide flow variability to maintain a diversity of emergent and riparian vegetation and to influence vegetation zonation patterns across the channel, which provide a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated on benches.	Short to medium	

Table A.7 : Reach 7 – Bunyip Estuary objectives.

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
Geomorphology	Maintain existing estuarine form and habitat	G7-1	Maintain substrates and prevent siltation	Low flow	All year	· Maintain substrate conditions and limit accumulation of fine sediments	Short	Revised wording of and consolidated objectives documented in EarthTech (2006b)
		G7-2	Maintain estuarine form	High flow	Winter / Spring	· Maintain estuarine features and depth	Medium to long	
				Bankfull	Anytime			
	Prevent gross change to estuarine form	G7-3	Prevent bed and bank erosion and protect existing substrates Limit frequency and duration of flows above scouring thresholds	Freshes / High flows	Throughout year	· Rate of rise/fall managed to minimise bank erosion/failure · Prevent any further increase in the frequency of flows above scouring thresholds	Short	
Fish	Maintain connectivity for migratory species (short-finned eel, long-finned eel, common galaxias, tupong, Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish, short-headed lamprey, pouched lamprey) between freshwater reaches and the sea	F7-1	Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from the sea.	Freshes / High flow	Spring / Early Summer	· Upstream immigration from the sea	Short	There is little permanent refuge for truly estuarine organisms. Flows throughout the estuary critical for maintaining connectivity for migratory species, attracting juvenile catadromous (tupong, eels) and amphidromous (grayling) and adult anadromous (lamprey) species into the river. Flow important for transporting eggs/larvae of grayling and diadromous galaxiids species to the sea, cue downstream migration of adult catadromous species (tupong, eel) to the sea to spawn. Changed objective so that is it more explicit as to the species and timing of migration. Upstream movement of diadromous fishes occurs over a broad time frame (e.g. August to February), with greatest richness of species migrating around September-November (McDowall & Eldon. 1980, Sloane 1984, Zampatti et al. 2003).
		F7-2	Cue upstream spawning migration by short-headed lamprey from the sea	Freshes / High flow	Late Winter / Spring	· Upstream immigration from the sea	Short	
		F7-3	Cue upstream spawning migration by pouched lamprey from the sea	Freshes / High flow	Winter / Spring	· Upstream immigration from the sea	Short	
		F7-4	Transport eggs and larvae of Australian grayling to the sea	High	Autumn	· Downstream drift of eggs and larvae to the sea	Short	Revised wording of objective and timing of high flow. Australian grayling undertakes downstream migrations to spawn between late March and May (Koster et al. 2017, Koster et al. 2013).
		F7-5	Maintain passage for migrations of tupong to the sea to spawn	Low flow / Freshes / High flow	Late Autumn / Winter	· Movement of adult fish into the sea to spawn	Short	New objective to cue downstream migration by tupong. Tupong undertake downstream migrations between late May and August, associated with high river flows (Crook et al. 2010).
		F7-6	Maintain passage for migrations of eels to the sea to spawn.	Low flow / Freshes / High flow	Late Summer / Early Autumn	· Movement of adult fish into the sea to spawn	Short	New objective to cue downstream migration by eels. Eels undertake downstream migrations throughout the year, with an increase in frequency over summer and following high river flows (Crook et al. 2014).
Vegetation	Maintain existing fringing salt marsh and swamp/estuarine scrub communities	V7-1	Maintain fringing salt marsh and swamp/estuarine scrub communities in the lower estuary.	Fresh	Summer / autumn	· Wet and maintain fringing salt marsh and salt scrub communities	Short to Medium	There seems to be almost no vegetation mapped along Reach 7 according to the interactive biodiversity mapping webpage. There is a tiny patch of EVC 53 Swamp Scrub along the very lowest section, along with a narrow band of EVC 8 Coastal Saltmarsh Aggregate. Estuarine Scrub
		V7-2	Maintain fringing salt marsh and swamp/estuarine scrub communities in the lower estuary.	Fresh	Winter / spring	· Wet and maintain fringing salt marsh and salt scrub communities	Short to Medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		V7-3				.		(EVC 953) may also be present. The only other notable vegetation is an area of EVC 914 Estuarine Flats Grassland, but it's 2 km to the west and not directly influenced by the Bunyip River. Clarification is required as to the presence and value of water-dependent vegetation that occurs in this reach.
Birds, Frogs and Amenity	Birds - Maintain or improve the species richness and abundance of streamside and wetland populations Frogs - Maintain diversity and improve the overall abundance and distribution of expected species Amenity - Maintain and/or improve condition	BFA7-1	Maintain access to good quality physical habitat, provide good water quality, and support the growth of estuarine vegetation, an important source of food resources and habitat	Low flow	Summer / autumn	· Maintain an adequate depth of water for habitat for biota such as macroinvertebrates, an important food source for birds and frogs · Provide disturbance to scour the river bed of sediment and improve the quality of instream habitat · Also provide a suitable range of depths for the growth of estuarine vegetation	Short to medium	Generic objectives have been included for Birds, Frogs and Amenity values.
		BFA7-2		Freshes	Summer / autumn	· Provide disturbance to scour the river bed of sediment and improve the quality of habitat within the river · Provide a suitable depth of water for waterbirds, maintaining the extent of habitat range they can utilise · Provide flow variability to maintain a diversity of vegetation and helps to influence vegetation zonation patterns, which then provide a variety of habitats.	Short to medium	
		BFA7-3	Rehabilitate and maintain habitat at the margins of the estuary	High flow	Summer / autumn	· Moves sediment along the river improving the quality of, and access to, instream habitat · Sustains longitudinal connectivity, providing opportunities to move along and between habitats for waterbirds. · Helps to influence vegetation zonation patterns, which provide a variety of habitats.	Short to medium	

Asset	Objective	No.	Function	Flow component	Timing	Expected response	Response time	Description of changes
		BFA7-4		Low flow	Winter / spring	· Increase habitat area for instream flora and fauna. · Encourages the die-back of terrestrial vegetation that has encroached down the bank during the summer low flow period	Short to medium	
		BFA7-5		Fresh	Winter / spring	· Provide flow variability to maintain a diversity of vegetation and to influence vegetation zonation patterns, which provide a variety of habitats for birds · Moves terrestrial organic matter along that has accumulated at the margins.	Short to medium	

Appendix B. Summary Flow Recommendations

Table B.1 : Summary of revised flow recommendations. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Season	Flow	Wet/Avg/Dry	Reach						
			1	2	3	4	5	6	7
Summer / Autumn (Dec- May)	Low flow	Wet/Avg	>10 ML/day (or natural)	20 ML/day (or natural)	5 ML/day (or natural)	>10 ML/day (or natural)	2 ML/day (or natural)	50 ML/Day	
		Dry							
	Fresh	Wet/Avg	35 ML/day (5/yr, 1-2 days at peak, or natural)	75 ML/day (5/yr, 2 days at peak)	10 ML/day (5/yr, 1-2 days at peak, or natural)	22 ML/day (5/yr, 2 days at peak, or natural)	8 ML/day (5/yr, 1-2 days at peak, or natural)	120 ML/day (5/yr, 2 days at peak, or natural)	
		Dry	35 ML/day (3/yr, 1-2 days at peak, or natural)	75 ML/day (3/yr, 2 days at peak)	10 ML/day (3/yr, 1-2 days at peak, or natural)	22 ML/day (3/yr, 2 days at peak, or natural)	8 ML/day (3/yr, 1-2 days at peak, or natural)	120 ML/day (3/yr, 2 days at peak, or natural)	
	High	Wet/Avg	Not Recommended	100 ML/day (1/yr in Apr/May, every year, 2 days at peak, event > 7 days duration)	Not Recommended	50 ML/day (1/yr in Apr/May, every year, 2 days at peak, event > 7 days duration)	Not Recommended	200 ML/day (1/yr in Apr/May, every year, 2 days at peak, event > 10 days duration)	
		Dry		100 ML/day (1/yr in Apr/May, must occur 2 in 3 yrs, 2 days at peak, event > 7 days duration)		50 ML/day (1/yr in Apr/May, must occur 2 in 3 yrs, 2 days at peak, event > 7 days duration)		150 ML/day (1/yr in Apr/May, must occur 2 in 3 yrs, 2 days at peak, event > 10 days duration)	
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	35 ML/day (or natural)	75 ML/day (or natural)	10 ML/day (or natural)	22 ML/Day (or natural)	8 ML/day (or natural)	50 ML/Day	
		Dry							
	Fresh	Wet/Avg	120 ML/day (3/yr, 1 event before Oct/Nov, 2 days at peak, or natural)	100-150 ML/day (1/yr in Jun/Jul, 2 days at peak)	30 ML/day (1/yr in Jun/Jul, 2 days at peak)	70 ML/day (1/yr in Jun/Jul, 2 days at peak)	20 ML/day (3/yr, 1 event before Oct/Nov, 2 days at peak, or natural)	350 - 550 ML/day (2/yr Jun-Sep, 1 event in Jun/Jul, 2 days at peak)	
				200 ML/day (1/yr, Jun-Sep, 2 days at peak)	30 ML/day (1/yr, Jun-Sep, 2 days at peak)	70 ML/day (1/yr, Jun-Sep, 2 days at peak)			
		Dry		100 ML/day (1/yr in Jun/Jul, 2 days at peak)	20 ML/day (1/yr in Jun/Jul, 2 days at peak)	70 ML/day (1/yr, Jun/Jul, 2 days at peak)		350 ML/day (1/yr, Jun/Jul, 2 days at peak)	
	High	Wet/Avg	Not Recommended	300 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	50 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	70 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	Not Recommended	1000 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	
		Dry		200 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	30 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	70 ML/day (1/yr in Sept/Oct, 2-3 days at peak, 7-10 days duration)		700 ML/day (1/yr in Sep/Oct, 2-3 days at peak, 7-10 days duration)	
	Bankfull	Wet/Avg	≥ 200 ML/day (1/yr, 2 days, or natural)	600 ML/Day (1/yr, 1 day, or natural)	100 ML/Day (1/yr, 2 days, or natural)	100 ML/Day (1/yr, 2 days, or natural)	50 ML/Day (1/yr, 2 days, or natural)	Not Recommended	
		Dry	Not expected, but let it occur naturally.						
	Overbank	Wet/Avg	≥ 300 ML/Day (1 in 2-3 yrs, 1 day, or natural)	1000 ML/Day (1 in 2 yrs, 1 day, or natural)	150 ML/day (1 in 2-3 yrs, 1 day, or natural)	200 ML/day (1 in 2-3 yrs, 1 day, or natural)	100 ML/day (1 in 2-3 yrs, 1 day, or natural)		
		Dry	Not expected, but let it occur naturally						
	Channel Maintenance	Wet/Avg	Not Recommended					1500 ML/Day (1 in 2 yrs, 1 day)	

Table B.2 : Summary of flow recommendations for Reach 1 – Upper Tarago River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Tarago River			Reach		Upper Tarago – Pederson Weir to Tarago Reservoir
Compliance point		Neerim			Gauge No		228206
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	>10 ML/day (or natural)				Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias and broad-finned galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G1-1, M1-1, F1-1, V1-1, P1-1, P1-2, BFA-1)
		Dry					
	Fresh	Wet/Avg	35 ML/day	5/yr (or natural)	1-2 days at peak (or natural)	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement and inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, maintain fringing aquatic vegetation, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. Facilitate dispersal of juvenile platypus. (G1-2, M1-3, F1-1, F1-3, V1-3, P1-3, BFA1-2)
		Dry	35 ML/day	3/yr (or natural)			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	35 ML/day (or natural)				Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias and broad-finned galaxias) platypus, birds and frogs, wet lower-bank vegetation, prevent recruitment of terrestrial plants in stream channel. (G1-1, M1-2, F1-1, V1-2, BFA1-3)
		Dry					
	Fresh	Wet/Avg	120 ML/day	3/yr (or natural), 1 event before Oct/Nov for broad-finned galaxias	2 days at peak (or natural)	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, maintain channel form and scour fine accumulated sediments from pools, provide opportunities for fish movement, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G1-2, G1-3, M1-4, M1-5, F1-1, F1-2, V1-4, P1-3, BFA1-4)
		Dry					
	Bankfull[1]	Wet/Avg	≥ 200 ML/day	1/yr (or natural)	2 days (or natural)	N/A	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules and entrain terrestrial carbon into stream. (G1-3, M1-6, V1-6, BFA1-5)
		Dry	Not expected, but let it occur naturally.				
	Overbank	Wet/Avg	≥ 300 ML/Day	1 in 2-3 yrs (or natural)	1 day (or natural)	N/A	Maintain riparian and floodplain vegetation, facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (V1-7, BFA1-6)
		Dry	Not expected, but let it occur naturally.				

[1]Bankfull / overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table B.3 : Summary of flow recommendations for Reach 2 – Lower Tarago River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Tarago River			Reach		Lower Tarago – Tarago Reservoir to Bunyip River
Compliance point		Drouin West			Gauge No.		228201
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	20 ML/day released from storage (or natural). Inflow from tributaries and local catchment run-off provide additional flow and required flow variation.				Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G2-1, M2-1, F2-1, V2-1, P2-1, P2-2, BFA2-1)
		Dry					
	Fresh	Wet/Avg	75 ML/day	5/yr	2 days at peak	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement and cue downstream migration by eels, facilitate juvenile dispersal of platypus, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Maintain oxygenated conditions during low flow periods. (G2-2, M2-3, M2-4, F2-1, F2-6, V2-3, P2-3, BFA2-2)
		Dry	75 ML/day	3/yr			
	High	Wet/Avg	100 ML/day	1/yr in Apr/May, every year	2 days at peak, event > 7 days duration	2.2/0.8	Maintain channel form and scour pools. Trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. May facilitate juvenile platypus dispersal. Prevent encroachment of terrestrial vegetation onto instream bars. (F2-4, F2-6, V2-5, BFA2-3)
		Dry	100 ML/day	1/yr in Apr/May. Must occur 2 in 3 years.			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	75 ML/day released from storage (or natural). Inflow from tributaries and local catchment run-off provide additional flow and required flow variation expected with greater tributary flows in winter / spring compared to summer / autumn season.				Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, wet lower-bank vegetation, and prevent recruitment of terrestrial plants in stream channel. (G2-1, M2-2, F2-1, V2-2, P2-1, P2-2, BFA2-4)
		Dry					
	Fresh	Wet/Avg	100-150 ML/day	1/yr in Jun/Jul	2 days at peak	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from downstream river reaches. Cue downstream migration by tupong and eels to the sea to spawn. Wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G2-2, M2-5, M2-6, F2-2, F2-3, F2-5, F2-6, V2-4, P2-3, BFA2-5)
			200 ML/day	1/yr, Jun-Sep	2 days at peak		
		Dry	100 ML/day	1/yr in Jun/Jul	2 days at peak		
	High	Wet/Avg	300 ML/day	1/yr in Sep/Oct	2-3 days at peak, 7-10 days duration.	2.2/0.8	As per fresh but provides prolonged disturbance to favour flood-tolerant vegetation; important role in preventing encroachment of terrestrial vegetation. (G2-2, M2-5, M2-6, F2-2, F2-3, F2-5, F2-6, V2-4, V2-6, P2-3, BFA2-5)
		Dry	200 ML/day				
	Bankfull[1]	Wet/Avg	600 ML/Day	1/yr (or natural)	1 day (or natural)	N/A	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G2-3, V2-7, P2-4, P2-5, BFA2-6)
		Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Wet/Avg	1000 ML/Day	1 in 2 yrs (or natural)	1 day (or natural)	N/A	Maintain riparian and floodplain vegetation, engage billabongs, provide wetted habitat for birds and frogs. (V2-8, BFA2-7)
		Dry	Not expected, but let it occur naturally.				

[1] Bankfull and Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 1-2 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For Bankfull and Overbank events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table B.4 : Summary of flow recommendations for Reach 3 – Labertouche Creek. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Labertouche Creek			Reach		Labertouche Creek
Compliance point		Longwarry North			Gauge No.		228290
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	5 ML/day (or natural)				Maintain suitable substrate conditions, maintain access to and area of habitat for bugs (including burrowing crayfish), fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, and common galaxias), platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G3-1, M3-1, F3-1, V3-1, P3-1, P3-2, BFA3-1)
		Dry					
	Fresh	Wet/Avg	10 ML/day	5/yr (or natural)	1-2 days at peak (or natural)	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, facilitate juvenile dispersal of platypus, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Prevent encroachment of terrestrial vegetation onto instream bars. Maintain oxygenated conditions during low flow periods. (G3-2, M3-3, M3-4, F3, F5, V3-3, V3-5, P3-3, BFA3-2)
		Dry	10 ML/day	3/yr (or natural)			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	10 ML/day (or natural)				Higher flows increase access to habitat for bugs (including burrowing crayfish), fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, and common galaxias) and platypus, wet lower-bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G3-1, M3-2, F3-1, V3-2, P3-1, BFA3-3)
		Dry					
	Fresh	Wet/Avg	30 ML/day	1/yr in Jun/Jul	2 days at peak	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G3-2, M3-5, M3-6, F3-2, F3-4, F3-5, V3-4, P3-3, BFA3-4)
			30 ML/day	1/yr Jun-Sep			
		Dry	20 ML/day	1/yr in Jun/Jul	2 days at peak		
	High	Wet/Avg	50 ML/day	1/yr in Sep/Oct	2-3 days at peak, 7-10 days duration.	2.2/0.8	As per fresh, higher flow also enhances scour in pools and provides prolonged disturbance to favour flood-tolerant vegetation; important role in preventing encroachment of terrestrial vegetation. (G3-3, F3-2, F3-5, V3-6)
		Dry	30 ML/day				
	Bankfull[1]	Wet/Avg	100 ML/day	1/yr (or natural)	2 days (or natural)	N/A	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G3-3, V3-7, BFA3-5)
		Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Wet/Avg	150 ML/day	1 in 2-3 yrs (or natural)	1 day (or natural)	N/A	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (M3-7, V3-8, BFA3-6)
		Dry	Not expected, but let it occur naturally.				

[1]Bankfull/ Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table B.5 : Summary of flow recommendations for Reach 4 – Upper Bunyip River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Upper Bunyip River			Reach		Upper Bunyip – Bunyip State Forest to Tarago River
Compliance point		Tonimbuk			Gauge No.		228212
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	>10 ML/day (or natural)				Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. G4-1, M4-1, F4-1, V4-1, P4-1, P4-2, BFA4-1)
		Dry					
	Fresh	Wet/Avg	22 ML/day	5/yr (or natural)	2 days at peak	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Facilitate dispersal of juvenile platypus. (G4-2, M4-3, F4-1, F4-5, F4-7, V4-3, V4-5, P4-3, BFA4-2)
		Dry	22 ML/day	3/yr (or natural)			
	High	Wet/Avg	50 ML/Day	1/yr in Apr/May, every year	2 days at peak, event > 7 days duration	2.2/0.8	Maintain channel form and scour pools. Trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. Prevent encroachment of terrestrial vegetation into stream channel and onto stream bars. May facilitate juvenile platypus dispersal. (G4-3, F4-2, F4-4, F4-7, V4-5, BFA4-3)
		Dry	50 ML/Day	1/yr in Apr/May. Must occur 2 in 3 years.			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	22 ML/Day (or natural)				Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, wet lower bank vegetation, prevent recruitment of terrestrial plants in stream channel. (G4-1, M4-2, F4-1, V4-2, P4-1, BFA4-4)
		Dry					
	Fresh	Wet/Avg	70 ML/day	1/yr in Jun/Jul	2 days at peak	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G4-2, M4-4, M4-5, F4-1, F4-2, F4-3, F4-6, F4-7, V4-4, P4-3, BFA4-5)
			70 ML/day	1/yr Jun-Sep			
		Dry	70 ML/day	1/yr in Jun/Jul	Min 2 days at peak.		
	High	Wet/Avg/Dry	70 ML/day	1/yr in Sep/Oct	2-3 days at peak, 7-10 days duration.	2.2/0.8	As per fresh, longer duration flow enhances scour in pools and provides prolonged disturbance to favour flood-tolerant vegetation and prevent encroachment of terrestrial vegetation onto stream bars. (G4-3, F4-2, F4-6, F4-7, V4-6)
	Bankfull[1]	Wet/Avg	100 ML/day	1/yr (or natural)	2 days (or natural)	N/A	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches and facilitate dispersion of propagules, help prevent encroachment of terrestrial vegetation entrain terrestrial carbon to the stream. (G4-3, M4-6, V4-7, P4-5, BFA4-6)
		Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Wet/Avg	200 ML/day	1 in 2-3 yrs (or natural)	1 day (or natural)	N/A	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (V4-8, BFA4-7)
		Dry	Not expected, but let it occur naturally.				

[1]BankfullOverbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table B.6 : Summary of flow recommendations for Reach 5 – Cannibal Creek. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Cannibal Creek			Reach		Cannibal Creek
Compliance point					Gauge No.		*New gauge installed in 2011*
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg Dry	2 ML/day (or natural)				Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong and broad-finned galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G5-1, M5-1, F5-1, F5-4, V5-1, P5-1, P5-2, P5-6, BFA5-1)
	Fresh	Wet/Avg	8 ML/day	5/yr (or natural)	1-2 days at peak (or natural)	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, facilitate dispersal of juvenile platypus, maintain fringing aquatic vegetation, prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G5-2, M5-3, F5-1, F5-5, F5-7, V5-3, V5-5, P5-3, BFA5-2)
		Dry	8 ML/day	3/yr (or natural)			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg Dry	8 ML/day (or natural)				Higher flows increase access to habitat for bugs, fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong and broad-finned galaxias) platypus, birds and frogs, wet lower-bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G5-1, M5-2, F5-1, V5-2, BFA5-3)
	Fresh	Wet/Avg Dry	20 ML/day	3/yr (or natural), 1 event before Oct/Nov for dwarf galaxias and broad-finned galaxias	2 days at peak (or natural)	2.2/0.8	Maintain suitable large wood habitat by periodically scouring sediments, inundate low-lying swamps for breeding of dwarf galaxias, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G5-2, G5-3, M5-4, M5-5, F5-3, F5-1, F5-2, F5-6, F5-7, P5-3, BFA5-4)
	Bankfull[1]	Wet/Avg	50 ML/day	1/yr (or natural)	2 days (or natural)	N/A	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, facilitate dispersion of propagules, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon to the stream. (G5-3, M5-6, V5-6, BFA5-5)
		Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Wet/Avg	100 ML/day	1/yr in 2-3 years (or natural)	1 day (or natural)	2.2/0.8	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (M5-6, V5-7, BFA5-6)
		Dry	Not expected, but let it occur naturally.				

[1]Bankfull/ Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table B.7 : Summary of flow recommendations for Reach 6 – Lower Bunyip River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Bunyip River			Reach		Lower Bunyip / Bunyip Main Drain
Compliance point		Iona			Gauge No.		228213
Season	Flow	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	50 ML/Day				Maintain sandy substrates and prevent siltation, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, dwarf galaxias, Australian grayling, short-finned eel, long-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, common galaxias, and Australian mudfish) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G6-1, M6-1, F6-1, V6-1, P6-1, P6-2, BFA6-1)
		Dry					
	Fresh	Wet/Avg	120 ML/Day	5/yr	2 days at peak	2.2/0.8	Maintain suitable pool, riffle, run habitat by periodically scouring sediment and biofilms, provide opportunities for fish movement and cue downstream migration by eels and facilitate juvenile dispersal of platypus. Maintain oxygenated conditions during low flow periods. (G6-3, M6-3, M6-5, F6-1, F6-6, P6-3, BFA6-2)
		Dry	120 ML/day	3/yr			
	High	Wet/Avg	200 ML/Day	1/yr Apr/May, every year	2 days at peak, event > 10 days duration	2.2/0.8	Flush accumulated fine sediments, trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. May facilitate juvenile platypus dispersal. (G6-3, F6-2, F6-4, F6-6, P6-4, BFA6-3)
		Dry	150 ML/Day	1/yr Apr/May, must occur 2 in 3 yrs			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	50 ML/Day				Maintain access to habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, dwarf galaxias, Australian grayling, short-finned eel, long-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, common galaxias, and Australian mudfish) platypus, birds and frogs, wet bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G6-1, M6-2, F6-1, V6-2, BFA6-4)
		Dry					
	Fresh	Wet/Avg	350 - 550 ML/day	2/yr Jun-Sep (1 event in Jun/Jul)	2 days at peak	2.2/0.8	Maintain sandy substrates and prevent siltation. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from downstream river reaches. Cue downstream migration by tupong and eels to the sea to spawn. (G6-3, M6-4, F6-1, F6-2, F6-5, F6-6, P6-3, BFA6-5)
		Dry	350 ML/day	1/yr Jun/Jul	2 days at peak		
	High	Wet/Avg	1000 ML/day	1/yr in Sep/ Oct	2-3 days at peak, 7-10 days duration.	2.2/0.8	As per fresh, higher flow also enhances scour in pools behind drop structures to maintain or improve quality and availability of habitats; also prevent encroachment of terrestrial vegetation into stream channel or instream bars. (G6-3, M6-4, F6-1, F6-2, F6-5, F6-6, P6-3, BFA6-6)
		Dry	700 ML/day	1/yr in Sep/Oct			
	Channel Maintenance[1]	Wet/Avg	1500 ML/day	1 in 2 yrs	1 day	N/A	Maintain channel form and scour pools behind drop structures, provide wetted habitat for birds and frogs. (G6-2, BFA6-7)
		Dry	Not expected, but let it occur naturally.				

[1]Channel Maintenance flows could occur at any time (in Summer also).

Table B.8 : Summary of flow recommendations for Reach 7 –Bunyip River Estuary. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream		Bunyip River			Reach		Bunyip Estuary
Compliance point		Koo Wee Rup			Gauge No.		228395
Season	Flow	Wet/Avg?Dry	Volume	Frequency and when	Duration	Rise/Fall	Objective (refer to objectives table for id reference)
Summer / Autumn (Dec-May)	Low flow	Wet/Avg	50 ML/Day				Maintain substrates and prevent siltation, maintain access to and area of habitat for fish (short-finned eel, long-finned eel, common galaxias, tupong, Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish, short-headed lamprey, pouched lamprey), birds and frogs. (G7-1, F7-5, F7-6, BFA7-1)
		Dry					
	Fresh	Wet/Avg	120 ML/Day	5/yr	2 days at peak	2.2/0.8	Maintain suitable habitat, provide opportunities for fish movement and maintain passage for migrations of eels to the sea to spawn. Maintain fringing salt marsh and salt scrub communities in the lower estuary. (G7-3, F7-6, V7-1, BFA7-2)
		Dry	120 ML/day	3/yr			
	High	Wet/Avg	200 ML/Day	1/yr Apr/May, every year	2 days at peak, event > 10 days duration	2.2/0.8	Flush accumulated fine sediments, transport eggs and larvae of Australian Grayling to the sea. Maintain passage for migrations of eels to the sea to spawn and provide opportunities for waterbirds to move between habitats. (G7-3, F7-4, F7-6, BFA7-3)
		Dry	150 ML/Day	1/yr Apr/May, must occur 2 in 3 yrs			
Winter / Spring (Jun-Nov)	Low flow	Wet/Avg	50 ML/Day				Maintain access to habitat for fish (short-finned eel, long-finned eel, common galaxias, tupong, Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish, short-headed lamprey, pouched lamprey) birds and frogs, wet lower-bank vegetation and prevent encroachment by terrestrial vegetation. (G7-1, F7-5, F7-6, BFA7-4)
		Dry					
	Fresh	Wet/Avg	350 - 550 ML/day	2/yr Jun-Sep (1 event in Jun/Jul)	2 days at peak	2.2/0.8	Maintain suitable substrates. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) and adult anadromous (short-headed lamprey, pouched lamprey) fishes from the sea. Maintain passage for migrations of tupong and eels to the sea to spawn. Maintain fringing salt marsh and swamp/estuarine scrub communities in the lower estuary. (G7-3, F7-1, F7-2, F7-3, F7-5, F7-6, V7-2, BFA7-5)
		Dry	350 ML/day	1/yr Jun/Jul	2 days at peak		
	High	Wet/Avg	1000 ML/day	1/yr in Sep/ Oct	2-3 days at peak, 7-10 days duration.	2.2/0.8	As per fresh, higher flow also enhances scour to maintain or improve quality and availability of habitats. (G7-2, F7-1, F7-2, F7-3, F7-5, F7-6, BFA7-3)
		Dry	700 ML/day	1/yr in Sep/Oct			
	Channel Maintenance[1]	Wet/Avg	1500 ML/day	1 in 2 yrs	1 day	N/A	Maintain estuarine form (G7-2)
		Dry	Not expected, but let it occur naturally.				

[1]Channel Maintenance flows could occur at any time (in Summer also).

Appendix C. Detailed Flow Recommendations

Table C.1 : Flow recommendations for Reach 1 – Upper Tarago River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Tarago River			Reach	Upper Tarago – Pederson Weir to Tarago Reservoir			
Compliance point	Neerim			Gauge No.	228206			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias and broad-finned galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G1-1, M1-1, F1-1, V1-1, P1-1, P1-2, BFA-1)	Wet/Average	>10 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs. No change in recommended volume.
			Dry					
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement and inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, maintain fringing aquatic vegetation, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. Facilitate dispersal of juvenile platypus. (G1-2, M1-3, F1-1, F1-3, V1-3, P1-3, BFA1-2)	Wet/Average	35 ML/day	5 events (or natural)	1-2 days at peak (or natural)	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values, with explicit reference to fish species (i.e. inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae). No change in recommended volume. Revised frequency and duration of fresh for wet/average years (5 events, 1-2 days at peak) and dry years (3 events, 1-2 days at peak) Revised rise/fall from 1.68/0.74 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	35 ML/day	3 events (or natural)	1-2 days at peak (or natural)		
Winter / Spring (Jun-Nov)	**Low flow**	Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias and broad-finned galaxias) platypus, birds and frogs, wet lower-bank vegetation, prevent recruitment of terrestrial plants in stream channel. (G1-1, M1-2, F1-1, V1-2, BFA1-3)	Wet/Average	35 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs, plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation. No change in recommended volume.
			Dry					
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, maintain channel form and scour fine accumulated sediments from pools, provide opportunities for fish movement, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G1-2, G1-3, M1-4, M1-5, F1-1, F1-2, V1-4, P1-3, BFA1-4)	Wet/Average	120 ML/day	3 events (or natural), at least 1 event before Oct/Nov for broad-finned galaxias	2 days at peak (or natural)	2.2/0.8	Revised objective to articulate role of winter/spring freshes for range of water dependent values. No change in recommended volume. Recommend one of the fresh event before Oct/Nov for broad-finned galaxias. Revised rise/fall from 1.68/0.74 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry					
	Bankfull[1]	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules and entrain terrestrial carbon into stream. (G1-3, M1-6, V1-6, BFA1-5)	Wet/Average	≥ 200 ML/day	1 event / year (or natural)	2 days (or natural)	N/A	Revised objective to articulate role of bankfull flow for range of water dependent values. No change in recommended volume. Revised frequency from 2 event / year to 1 event / year. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Maintain riparian and floodplain vegetation, facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (V1-7, BFA1-6)	Wet/Average	≥ 300 ML/Day	1 event in 2-3 years (or natural)	1 day (or natural)	N/A	Minor changes to wording of objective. No change in recommended volume. Revised frequency from 1 event / year to 1 event in 2-3 years. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				

[1]Bankfull / overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table C.2 : Flow recommendations for Reach 2 – Lower Tarago River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Tarago River			Reach	Lower Tarago – Tarago Reservoir to Bunyip River			
Compliance point	Drouin West			Gauge No.	228201			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G2-1, M2-1, F2-1, V2-1, P2-1, P2-2, BFA2-1)	Wet/Average	20 ML/day released from storage (or natural). Inflow from tributaries and local catchment run-off provide additional flow and required flow variation.				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs. Previous recommended low flow considered too low. Increased low flow recommendation from > 12 ML/day to 20 ML/day, so as to provide additional depth and width of flow (increase in riffle area and access for platypus)
			Dry					
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement and cue downstream migration by eels, facilitate juvenile dispersal of platypus, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Maintain oxygenated conditions during low flow periods. (G2-2, M2-3, M2-4, F2-1, F2-6, V2-3, P2-3, BFA2-2)	Wet/Average	75 ML/day released from storage plus flow from tributaries on top of this provide increased magnitude and variability during average and wet years.	Minimum 5 events delivered + additional events provided by incoming tributaries	Min 2 day at peak, additional duration provided by incoming tributaries	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values (i.e. cue downstream migration by eels, facilitate juvenile dispersal of platypus) Revised volume, timing and duration of fresh for wet/average and dry years. Reduced volume from 100 ML/day to 75 ML/day and duration from 4 days to 2 days at peak. Acknowledge additional inflows to this reach from incoming tributaries. Revised rise/fall from 1.77/0.72 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	75 ML/day	3 events	Min 2 day at peak		
	High	Maintain channel form and scour pools. Trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. May facilitate juvenile platypus dispersal. Prevent encroachment of terrestrial vegetation onto instream bars. (F2-4, F2-6, V2-5, BFA2-3)	Wet/Average	100 ML/day	1 event in April/May, every year	Min 2 day at peak for event greater than 7 days duration (including ramp up and ramp down)	2.2/0.8	Revised objective to articulate role of summer/autumn high for range of water dependent values, in particular fish species (spawning of Australia Grayling and transport of larvae downstream, cue downstream migration of eels). Revised timing of high for wet/average and dry years. Event in April/May to cue downstream migration of Australian grayling. Event required 2 in 3 years, prioritise this. Spawning data from the Bunyip River show that the duration of flow events associated with peak spawning of Australian grayling ranges broadly, but typically might be around 10-15 days or longer. Recommendation of > 7 days considered ok in the upper reaches (as here fish are using the flow cue to commence migration), but in the lower reaches, a longer duration (e.g. 10 days) is considered important as once fish migrate to the lower reaches, they also need suitable conditions to spawn. Revised rise/fall from 1.77/0.72 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	100 ML/day	1 event in April/May. Must occur 2 in 3 years.	Min 2 day at peak for event greater than 7 days duration (including ramp up and ramp down)		
Winter / Spring Jun-Nov)	**Low flow**	Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, wet lower-bank vegetation, and prevent	Wet/Average	75 ML/day released from storage (or natural). Inflow from tributaries and local catchment run-off provide additional flow and required flow variation expected with greater tributary flows in winter / spring compared to summer / autumn season.				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation.
			Dry					

		recruitment of terrestrial plants in stream channel. (G2-1, M2-2, F2-1, V2-2, P2-1, P2-2, BFA2-4)						Previous recommended low flow considered too high (wet/average 100 ML/day and dry 86 ML/day). Lowered volume of low flow for wet/average and dry years to 75 ML/day.
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from downstream river reaches. Cue downstream migration by tupong and eels to the sea to spawn. Wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G2-2, M2-5, M2-6, F2-2, F2-3, F2-5, F2-6, V2-4, P2-3, BFA2-5)	Wet/Average	100-150 ML/day, tributary inflows provide variation during average and wet years. Higher magnitude and longer duration flows are acceptable and beneficial in average and wet years.	1 event occurring in June or July to facilitate migration of fish	Min 2 days at peak. Longer duration flows acceptable in average and wet years.	2.2/0.8	Revised objective to articulate role of winter/spring freshes for range of water dependent values, with explicit reference to specific fish species. Revised volume, timing and duration of winter / spring fresh recommendation documented in EarthTech (2007). Previous recommended fresh considered too high (280 ML/day). Changed from 1 Fresh for 4 days to two freshes in wet/average years, min 2 days at peak: · 100-150 ML/day in June or July to facilitate migration of fish. · 200 ML/day between June and September - higher flow to maintain flood-tolerant vegetation higher on banks. In dry years, only one fresh in June or July with a lower volume of 100 ML/day. Second fresh between June and September not expected to occur in dry years but allow to occur naturally. Revised rise/fall from 1.77/0.72 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
				200 ML/day	1 event between June and September to facilitate migration of fish and maintain flood-tolerant vegetation higher on banks	Min 2 days at peak. Longer duration flows acceptable in average and wet years.		
			Dry	100 ML/day	1 event occurring in June or July to facilitate migration of fish (not required every year, but would benefit)	Min 2 days at peak.		
	High	As per fresh but provides prolonged disturbance to favour flood-tolerant vegetation; important role in preventing encroachment of terrestrial vegetation. (G2-2, M2-5, M2-6, F2-2, F2-3, F2-5, F2-6, V2-4, V2-6, P2-3, BFA2-5)	Wet/Average	300 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.	2.2/0.8	New flow recommendation, provides prolonged disturbance to favour flood-tolerant vegetation and to help prevent encroachment by terrestrial vegetation. Revised rise/fall from 1.77/0.72 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	200 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		
	Bankfull[1]	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G2-3, V2-7, P2-4, P2-5, BFA2-6)	Wet/Average	600 ML/Day	1 event per year (or natural)	1 day (or natural)	N/A	Revised objective to articulate role of bankfull flow for range of water dependent values, in particular geomorphology and vegetation. No change in recommended volume. These are natural flow events not managed flows. Changed rise/fall to N/A as there is no control over this. Removed channel maintenance flow recommendation documented in EarthTech (2007).
			Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Maintain riparian and floodplain vegetation, engage billabongs, provide wetted habitat for birds and frogs. (V2-8, BFA2-7)	Wet/Average	1000 ML/Day	1 in 2 years (or natural)	1 day (or natural)	N/A	Revised objective to include reference to billabongs. No change in recommended volume. These are natural flow events not managed flows. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				

[1] Bankfull and Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 1-2 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For Bankfull and Overbank events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table C.3 : Flow recommendations for Reach 3 – Labertouche Creek. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Labertouche Creek			Reach	Labertouche Creek			
Compliance point	Longwarry North			Gauge No.	228290			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain suitable substrate conditions, maintain access to and area of habitat for bugs (including burrowing crayfish), fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, and common galaxias), platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G3-1, M3-1, F3-1, V3-1, P3-1, P3-2, BFA3-1)	Wet/Average Dry	5 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs. New flow recommendation developed following an analysis of flow duration curves. 5 ML/day corresponds with 40^{h} percentile of flows for Summer/Autumn flow season.
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, facilitate juvenile dispersal of platypus, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Prevent encroachment of terrestrial vegetation onto instream bars. Maintain oxygenated conditions during low flow periods. (G3-2, M3-3, M3-4, F3, F5, V3-3, V3-5, P3-3, BFA3-2)	Wet/Average	10 ML/day	5 events (or natural)	1-2 days at peak (or natural)	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values, with explicit reference to fish species (i.e. inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae). New flow recommendation developed following an analysis of flow duration curves and spells analysis of wet/average and dry years. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	10 ML/day	3 events (or natural)	1-2 days at peak (or natural)		
Winter / Spring (Jun-Nov)	**Low flow**	Higher flows increase access to habitat for bugs (including burrowing crayfish), fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, and common galaxias) and platypus, wet lower-bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G3-1, M3-2, F3-1, V3-2, P3-1, BFA3-3)	Wet/Average Dry	10 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs, plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation. New flow recommendation developed following an analysis of flow duration curves and spells analysis. Magnitude of recommended Winter / Spring low flow also corresponds with Summer / Autumn fresh.
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream.	Wet/Average	30 ML/day	1 event occurring in June or July to facilitate migration of fish	Min 2 days at peak. Longer duration flows acceptable in average and wet years.	2.2/0.8	Revised objective to articulate role of winter/spring fresh for range of water dependent values, with explicit reference to specific fish species. Recommend similar pattern to Reaches, 2, 4, 6. Two freshes in wet/average years, min 2 days at peak: · 30 ML/day in June or July to facilitate migration of fish. · 30 ML/day between June and September - higher flow to maintain flood-tolerant vegetation higher on banks.
				30 ML/day	1 event between June and September to facilitate migration of fish and maintain flood-tolerant vegetation higher on banks	Min 2 days at peak. Longer duration flows acceptable in		

Stream	Labertouche Creek			Reach	Labertouche Creek			
Compliance point	Longwarry North			Gauge No.	228290			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
		(G3-2, M3-5, M3-6, F3-2, F3-4, F3-5, V3-4, P3-3, BFA3-4)				average and wet years.		In dry years, only one fresh in June or July with a lower volume of 20 ML/day. Second fresh between June and September not expected to occur in dry years but allow to occur naturally. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	20 ML/day	1 event occurring in June or July to facilitate migration of fish (not required every year, but would benefit)	Min 2 days at peak		
	High	As per fresh, higher flow also enhances scour in pools and provides prolonged disturbance to favour flood-tolerant vegetation; important role in preventing encroachment of terrestrial vegetation. (G3-3, F3-2, F3-5, V3-6)	Wet/Average	50 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.	2.2/0.8	Flow recommendation to connect with magnitude and timing of recommended high flow in Reach 2, 4 and 6. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	30 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		
	Bankfull[1]	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, help prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G3-3, V3-7, BFA3-5)	Wet/Average	100 ML/day	1 event per year (or natural)	2 days (or natural)	N/A	Revised objective to articulate role of bankfull flow for range of water dependent values, in particular geomorphology and vegetation. Volume of bankfull flow determined following a review of cross-section and stage/discharge rating curve at gauge and spells analysis. These are natural flow events not managed flows. Rise/fall N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (M3-7, V3-8, BFA3-6)	Wet/Average	150 ML/day	1 event in 2-3 years (or natural)	1 day (or natural)	N/A	Minor changes to wording of objective. Volume of overbank flow determined following a review of cross-section and stage/discharge rating curve at gauge and spells analysis. Rise/fall N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				

[1]Bankfull/ Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table C.4 : Flow recommendations for Reach 4 - Upper Bunyip River. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Upper Bunyip River			Reach	Upper Bunyip – Bunyip State Forest to Tarago River			
Compliance point	Tonimbuk			Gauge No.	228212			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G4-1, M4-1, F4-1, V4-1, P4-1, P4-2, BFA4-1)	Wet/Average Dry	>10 ML/day (or natural)				Revised objective so that it includes explicit reference to native fish species in this reach and also includes reference to platypus, birds and frogs. No change in recommended volume.
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, maintain fringing aquatic vegetation and facilitate dispersion of propagules. Facilitate dispersal of juvenile platypus. (G4-2, M4-3, F4-1, F4-5, F4-7, V4-3, V4-5, P4-3, BFA4-2)	Wet/Average Dry	22 ML/day 22 ML/day	5 events (or natural) 3 events (or natural)	2 days at peak 2 days at peak	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values, with explicit reference to fish species (i.e. inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels). No change in recommended volume. Revised frequency and duration of fresh for wet/average (5 events, 2 days at peak) and dry years (3 events, 2 days at peak). Revised rise/fall from 2.00/0.71 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
	High	Maintain channel form and scour pools. Trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. Prevent encroachment of terrestrial vegetation into stream channel and onto stream bars. May facilitate juvenile platypus dispersal. (G4-3, F4-2, F4-4, F4-7, V4-5, BFA4-3)	Wet/Average Dry	50 ML/Day 50 ML/Day	1 event in April/May, every year 1 event in April/May. Must occur 2 in 3 years.	Min 2 day at peak for event greater than 7 days duration (including ramp up and ramp down) Min 2 day at peak for event greater than 7 days duration (including ramp up and ramp down)	2.2/0.8	Revised objective to articulate role of summer/autumn high for range of water dependent values, in particular fish species (spawning of Australia Grayling and transport of larvae downstream, cue downstream migration of eels) and to help prevent encroachment of terrestrial vegetation. Revised volume, timing and duration of high flow for wet/average and dry years. Reduced recommended volume from 175 ML/day to 50 ML/day. In wet/average years, 1 event in April/May, every year. In dry years, event required 2 in 3 years, prioritise this. Spawning data from the Bunyip River show that the duration of flow events associated with peak spawning of Australian grayling ranges broadly, but typically might be around 10-15 days or longer. Recommendation of > 7 days considered ok in the upper reaches (as here fish are using the flow cue to commence migration), but in the lower reaches, a longer duration (e.g. 10 days) is considered important as once fish migrate to the lower reaches, they also need suitable conditions to spawn. Revised rise/fall from 2.00/0.71 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
Winter / Spring (Jun-Nov)	**Low flow**	Higher flows increase access to habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, Australian grayling, short-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, and common galaxias) platypus, birds and frogs, wet	Wet/Average Dry	22 ML/Day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs, plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation. Revised objective so that it includes explicit reference to native fish species in this reach and also includes reference to platypus. No change in recommended volume.

Stream	Upper Bunyip River			Reach	Upper Bunyip – Bunyip State Forest to Tarago River			
Compliance point	Tonimbuk			Gauge No.	228212			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
		lower bank vegetation, prevent recruitment of terrestrial plants in stream channel. (G4-1, M4-2, F4-1, V4-2, P4-1, BFA4-4)						
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G4-2, M4-4, M4-5, F4-1, F4-2, F4-3, F4-6, F4-7, V4-4, P4-3, BFA4-5)	Wet/Average	70 ML/day	1 event occurring in June or July to facilitate migration of fish	Min 2 days at peak. Longer duration flows acceptable in average and wet years.	2.2/0.8	Revised objective to articulate role of winter/spring fresh for range of water dependent values, with explicit reference to specific fish species. No change in recommended volume. Revised timing and duration of winter / spring fresh recommendation documented in EarthTech (2007). Previous recommended fresh 70 ML/day, 4 events including 1 in late Oct-Nov, 3 day duration. Changed to two freshes in wet/average years, min 2 days at peak: · 70 ML/day between June and September (1 event in June or July) to facilitate migration of fish and maintain flood-tolerant vegetation higher on banks. In dry years, only one fresh in June or July. Second fresh between June and September not expected to occur in dry years but allow to occur naturally. Revised rise/fall from 2.00/0.71 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
				70 ML/day	1 event between June and September to facilitate migration of fish and maintain flood-tolerant vegetation higher on banks	Min 2 days at peak. Longer duration flows acceptable in average and wet years.		
			Dry	70 ML/day	1 event occurring in June or July to facilitate migration of fish (not required every year, but would benefit)	Min 2 days at peak.		
	High	As per fresh, longer duration flow enhances scour in pools and provides prolonged disturbance to favour flood-tolerant vegetation and prevent encroachment of terrestrial vegetation onto stream bars. (G4-3, F4-2, F4-6, F4-7, V4-6)	Wet/Average	70 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		New flow recommendation to connect with magnitude and timing of recommended high flow in Reach 2 and 6.
			Dry	70 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		
	Bankfull[1]	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches and facilitate dispersion of propagules, help prevent encroachment of terrestrial vegetation entrain terrestrial carbon to the stream. (G4-3, M4-6, V4-7, P4-5, BFA4-6)	Wet/Average	100 ML/day	1 event per year (or natural)	2 days (or natural)	N/A	Revised objective to articulate role of bankfull flow for range of water dependent values, in particular geomorphology and vegetation. No change in recommended volume. Revised frequency and duration from 4 events, 3 day duration to 1 event, 2 day duration in wet/average years (not expected to occur in dry years). These are natural flow events not managed flows. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				
	Overbank[1]	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (V4-8, BFA4-7)	Wet/Average	200 ML/day	1 event in 2-3 years (or natural)	1 day (or natural)	N/A	Minor changes to wording of objective. No change in recommended volume. Revised frequency from 1 event / year to 1 event in 2-3 years and duration of 3 days to 1 day. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				

[1]BankfullOverbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table C.5 : Flow recommendations for Reach 5 – Cannibal Creek. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Cannibal Creek			Reach	Cannibal Creek			
Compliance point				Gauge No.	*New gauge installed in 2011*			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain suitable substrate conditions, maintain access to and area of habitat for bugs, fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong and broad-finned galaxias) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G5-1, M5-1, F5-1, F5-4, V5-1, P5-1, P5-2, P5-6, BFA5-1)	Wet/Average	2 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs. New flow recommendation based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road. Low flow will provide 10-15 cm flow depth in riffle and 30-40 cm depth in pool (refer to Figure 1.4 and Figure 1.5). Low flow could include cease to flow, providing that the pools do not dry out. Acceptable period of cease flow still to be determined as part of an extension to the 'Cannibal Creek flow and asset assessment project'.
			Dry					
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, provide opportunities for fish movement, inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae, cue downstream migration by eels, facilitate dispersal of juvenile platypus, maintain fringing aquatic vegetation, prevent encroachment of terrestrial vegetation and facilitate dispersion of propagules. (G5-2, M5-3, F5-1, F5-5, F5-7, V5-3, V5-5, P5-3, BFA5-2)	Wet/Average	8 ML/day	5 events (or natural)	1-2 days at peak (or natural)	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values, with explicit reference to fish species (i.e. inundate stream margins for spawning by broad-finned galaxias and downstream transport of larvae). New flow recommendation based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road. 8 ML/day fresh would periodically inundate and water vegetation on low bench at XS3 (refer to Figure 1.4 and Figure 1.5). Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	8 ML/day	3 events (or natural)	1-2 days at peak (or natural)		
Winter / Spring Jun-Nov)	**Low flow**	Higher flows increase access to habitat for bugs, fish (dwarf galaxias, river blackfish, southern pygmy perch, short-finned eel, short-headed lamprey, pouched lamprey, tupong and broad-finned galaxias) platypus, birds and frogs, wet lower-bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G5-1, M5-2, F5-1, V5-2, BFA5-3)	Wet/Average	8 ML/day (or natural)				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs, plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation. New flow recommendation based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road. Low flow of 8 ML/day would permanently inundate low bench at XS3 and provide water depths of 30 cm at riffle and 50-60 cm in pool (refer to Figure 1.4 and Figure 1.5).
			Dry					
	Fresh	Maintain suitable large wood habitat by periodically scouring sediments, inundate low-lying swamps for breeding of dwarf galaxias, provide fish passage and facilitate upstream immigration of juvenile catadromous (short-finned eel, common galaxias, tupong) fishes from downstream river reaches, cue migration of eels, wet higher benches to maintain vertical zonation of fringing vegetation, help prevent encroachment of terrestrial vegetation and entrain terrestrial carbon into stream. (G5-2, G5-3, M5-4, M5-5, F5-3, F5-1, F5-2, F5-6, F5-7, P5-3, BFA5-4)	Wet/Average	20 ML/day	3 events (or natural), at least 1 event before Oct/Nov for dwarf galaxias and broad-finned galaxias	2 days at peak (or natural)	2.2/0.8	Revised objective to articulate role of winter/spring freshes for range of water dependent values. New flow recommendation of 20 ML/day based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road. Recommend one of the fresh event before Oct/Nov for dwarf galaxias and broad-finned galaxias. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry					
	Bankfull[1]	Maintain channel form and scour fine accumulated sediments from pools, maintain vegetation on higher benches, facilitate dispersion of propagules, help	Wet/Average	50 ML/day	1 event per year (or natural)	2 days (or natural)	N/A	Revised objective to articulate role of bankfull flow for range of water dependent values, in particular geomorphology and vegetation.
			Dry	Not expected, but let it occur naturally.				

Stream	Cannibal Creek			Reach	Cannibal Creek			
Compliance point				Gauge No.	*New gauge installed in 2011*			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
		prevent encroachment of terrestrial vegetation and entrain terrestrial carbon to the stream. (G5-3, M5-6, V5-6, BFA5-5)						New bankfull flow recommendation of 50 ML/day based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road. These are natural flow events not managed flows. Rise/fall N/A as there is no control over this.
	Overbank[1]	Maintain riparian and floodplain vegetation and facilitate dispersion of propagules, provide wetted habitat for birds and frogs. (M5-6, V5-7, BFA5-6)	Wet/Average	100 ML/day	1 event in 2-3 years (or natural)	1 day (or natural)	N/A	Minor changes to wording of objective. No change in recommended volume. Rise/fall N/A as there is no control over this. New overbank flow recommendation of 100 ML/day based on a review of Jacobs (2017a), site photographs and hydraulic model for Cannibal Creek site at Wimpole Road.
			Dry	Not expected, but let it occur naturally.				

[1]Bankfull/ Overbank flows could occur at any time (in Summer also). While these are natural flows, their occurrence during November to February period may compromise juvenile platypus recruitment.

7 day independence is recommended between events.

Flow recommendations for each flow component do not have to be discrete. For example, an overbank event recommended once every 2-3 years will also satisfy the requirement for a bankfull event and one of the Winter / Spring freshes.

The 'or natural' clause attached to the low flow recommendations indicate that flow is recommended to be equal to or above the value specified for that season except when flows naturally fall below that value. For the freshes and larger events, the 'or natural' clause refers to the frequency and duration of the event. That is, the event must occur for the duration and frequency specified unless the particular event would be naturally less frequent or of a shorter duration. In both cases, where the 'natural' clause is applied, the recommendation is met.

Table C.6 : Flow recommendations for Reach 6 – Lower Bunyip / Bunyip Main Drain. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Bunyip River			Reach	Lower Bunyip / Bunyip Main Drain			
Compliance point	Iona			Gauge No.	228213			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain sandy substrates and prevent siltation, maintain access to and area of habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, dwarf galaxias, Australian grayling, short-finned eel, long-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, common galaxias, and Australian mudfish) platypus, birds and frogs, maintain drought refuge pool and instream vegetation. (G6-1, M6-1, F6-1, V6-1, P6-1, P6-2, BFA6-1)	Wet/Average Dry	50 ML/Day				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs. No change in recommended volume from EarthTech (2007)
	Fresh	Maintain suitable pool, riffle, run habitat by periodically scouring sediment and biofilms, provide opportunities for fish movement and cue downstream migration by eels and facilitate juvenile dispersal of platypus. Maintain oxygenated conditions during low flow periods. (G6-3, M6-3, M6-5, F6-1, F6-6, P6-3, BFA6-2)	Wet/Average	120 ML/Day	Minimum 5 events	Min 2 day at peak	2.2/0.8	Revised objective to articulate role of summer/autumn freshes for range of water dependent values (i.e. cue downstream migration by eels, facilitate juvenile dispersal of platypus) No change in recommended volume from EarthTech (2007). Revised frequency and timing of fresh for wet/average and dry years so that it is consistent with Reach 2. Revised rise/fall from 1.56/0.75 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	120 ML/day	3	2		
	High	Flush accumulated fine sediments, trigger downstream spawning migration of Australian Grayling. Cue downstream migration of eels. May facilitate juvenile platypus dispersal. (G6-3, F6-2, F6-4, F6-6, P6-4, BFA6-3)	Wet/Average	200 ML/Day	1 (April/May) every year	Min 2 day at peak for event greater than 10 days duration (including ramp up and ramp down)	2.2/0.8	Revised objective to articulate role of summer/autumn high for range of water dependent values, in particular fish species (spawning of Australia Grayling and transport of larvae downstream, cue downstream migration of eels). Revised volume and timing of high for wet/average and dry years. No change in recommended volume from EarthTech (2007) for wet/average years. In dry years, lower recommendation of 150 ML/day. Event in April/May to cue downstream migration of Australian grayling. Event required 2 in 3 years, prioritise this. Spawning data from the Bunyip River show that the duration of flow events associated with peak spawning of Australian grayling ranges broadly, but typically might be around 10-15 days or longer. Recommendation of > 7 days considered ok in the upper reaches (as here fish are using the flow cue to commence migration), but in the lower reaches, a longer duration (e.g. 10 days) is considered important as once fish migrate to the lower reaches, they also need suitable conditions to spawn. Extended duration of event provided by addional catchment inflows (i.e. Upper Bunyip River). Revised rise/fall from 1.56/0.75 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	150 ML/Day	1 (April/May). Must occur at least twice in three years.	Min 2 day at peak for event greater than 10 days duration (including ramp up and ramp down)		
Winter / Spring (Jun-Nov)	**Low flow**	Maintain access to habitat for bugs, fish (river blackfish, ornate galaxias, southern pygmy perch, dwarf galaxias, Australian	Wet/Average Dry	50 ML/Day				Revised objective, includes explicit reference to native fish species in this reach, platypus, birds and frogs, plus role of permanent inundation of entire stream bed for preventing encroachment by terrestrial vegetation.

Stream	Bunyip River			Reach	Lower Bunyip / Bunyip Main Drain			
Compliance point	Iona			Gauge No.	228213			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
		grayling, short-finned eel, long-finned eel, short-headed lamprey, pouched lamprey, tupong, broad-finned galaxias, spotted galaxias, common galaxias, and Australian mudfish) platypus, birds and frogs, wet bank vegetation and prevent recruitment of terrestrial plants in stream channel. (G6-1, M6-2, F6-1, V6-2, BFA6-4)						EarthTech (2007) previously recommended low flow of 50 ML/Day (June-Sept) and 70 ML/Day (Oct-Nov). Updated low flow recommendation as 50 ML/day throughout season.
	Fresh	Maintain sandy substrates and prevent siltation. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish) fishes from downstream river reaches. Cue downstream migration by tupong and eels to the sea to spawn. (G6-3, M6-4, F6-1, F6-2, F6-5, F6-6, P6-3, BFA6-5)	Wet/Average	350 - 550 ML/day	2 events between June and September (1 event in June or July) to facilitate migration of fish	Min 2 days at peak. Longer duration flows acceptable in average and wet years.	2.2/0.8	Revised objective to articulate role of winter/spring fresh for range of water dependent values, with explicit reference to specific fish species. Revised volume, timing and duration of winter / spring fresh recommendation documented in EarthTech (2007). Recommended volume based on analysis of recommended flow events in Reach 2 and how these translate with volume of flows in Reach 6. Changed from 1 Fresh for 4 days to two freshes in wet/average years, min 2 days at peak: · 350 - 550 ML/day between June and September (1 event in June or July) to facilitate migration of fish. In dry years, only one fresh in June or July with a lower volume of 350 ML/day. Second fresh between June and September not expected to occur in dry years but allow to occur naturally. Revised rise/fall from 1.56/0.75 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	350 ML/day	1 event occurring in June or July to facilitate migration of fish (not required every year, but would benefit)	Min 2 days at peak.		
	High	As per fresh, higher flow also enhances scour in pools behind drop structures to maintain or improve quality and availability of habitats; also prevent encroachment of terrestrial vegetation into stream channel or instream bars. (G6-3, M6-4, F6-1, F6-2, F6-5, F6-6, P6-3, BFA6-6)	Wet/Average	1000 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.	2.2/0.8	Revised flow recommendation to connect with magnitude and timing of recommended high flow in Reach 2. Revised rise/fall from 1.56/0.75 to 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	700 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		
	Channel Maintenance[1]	Maintain channel form and scour pools behind drop structures, provide wetted habitat for birds and frogs. (G6-2, BFA6-7)	Wet/Average	1500 ML/day	1 in 2 years	1 day	N/A	No change in recommended volume. These are natural flow events not managed flows. Changed rise/fall to N/A as there is no control over this.
			Dry	Not expected, but let it occur naturally.				

[1]Channel Maintenance flows could occur at any time (in Summer also).

Table C.7 : Flow recommendations for Reach 7 – Bunyip River Estuary. Flow components have been colour coded to highlight those that are managed (blue) from those that are natural (green).

Stream	Bunyip River			Reach	Bunyip Estuary			
Compliance point	Koo Wee Rup			Gauge No.	228395			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
Summer / Autumn (Dec-May)	**Low flow**	Maintain substrates and prevent siltation, maintain access to and area of habitat for fish (short-finned eel, long-finned eel, common galaxias, tupong, Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish, short-headed lamprey, pouched lamprey), birds and frogs. (G7-1, F7-5, F7-6, BFA7-1)	Wet/Average	50 ML/Day				Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream.
			Dry					
	Fresh	Maintain suitable habitat, provide opportunities for fish movement and maintain passage for migrations of eels to the sea to spawn. Maintain fringing salt marsh and salt scrub communities in the lower estuary. (G7-3, F7-6, V7-1, BFA7-2)	Wet/Average	120 ML/Day	Minimum 5 events	Min 2 days at peak	2.2/0.8	Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	120 ML/day	3 events	Min 2 days at peak		
	High	Flush accumulated fine sediments, transport eggs and larvae of Australian Grayling to the sea. Maintain passage for migrations of eels to the sea to spawn and provide opportunities for waterbirds to move between habitats. (G7-3, F7-4, F7-6, BFA7-3)	Wet/Average	200 ML/Day	1 (April/May) every year	Min 2 day at peak for event greater than 10 days duration (including ramp up and ramp down)	2.2/0.8	Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	150 ML/Day	1 (April/May). Must occur at least twice in three years.	Min 2 day at peak for event greater than 10 days duration (including ramp up and ramp down)		
Winter / Spring (Jun-Nov)	**Low flow**	Maintain access to habitat for fish (short-finned eel, long-finned eel, common galaxias, tupong, Australian grayling, broad-finned galaxias, spotted galaxias, Australian mudfish, short-headed lamprey, pouched lamprey) birds and frogs, wet lower-bank vegetation and prevent encroachment by terrestrial vegetation. (G7-1, F7-5, F7-6, BFA7-4)	Wet/Average	50 ML/Day				Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream.
			Dry					
	Fresh	Maintain suitable substrates. Provide opportunities for fish movement. Facilitate upstream immigration of juvenile catadromous (short-finned eel, long-finned eel, common galaxias, tupong) and amphidromous (Australian grayling, broad-finned galaxias, spotted	Wet/Average	350 - 550 ML/day	2 events between June and September (1 event in June or July) to facilitate migration of fish	Min 2 days at peak. Longer duration flows acceptable in average and wet years.	2.2/0.8	Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.

Stream	Bunyip River			Reach	Bunyip Estuary			
Compliance point	Koo Wee Rup			Gauge No.	228395			
Season	Flow	Objective (refer to objectives table for id reference)	Wet/Avg/Dry	Volume	Frequency and when	Duration	Rise/Fall	Description of changes
		galaxias, Australian mudfish) and adult anadromous (short-headed lamprey, pouched lamprey) fishes from the sea. Maintain passage for migrations of tupong and eels to the sea to spawn. Maintain fringing salt marsh and swamp/estuarine scrub communities in the lower estuary. (G7-3, F7-1, F7-2, F7-3, F7-5, F7-6, V7-2, BFA7-5)	Dry	350 ML/day	1 event occurring in June or July to facilitate migration of fish (not required every year, but would benefit)	Min 2 days at peak		
	High	As per fresh, higher flow also enhances scour to maintain or improve quality and availability of habitats. (G7-2, F7-1, F7-2, F7-3, F7-5, F7-6, BFA7-3)	Wet/Average	1000 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.	2.2/0.8	Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream. Recommend rate of rise/fall 2.2/0.8. These still lie within the 50-80th percentile and are considered conservative.
			Dry	700 ML/day	1 event in September / October	2-3 days at peak, 7-10 days total duration.		
	Channel Maintenance[1]	Maintain estuarine form (G7-2)	Wet/Average	1500 ML/Day	1 in 2 years (or natural)	1 day (or natural)	*N/A*	Reach 6 flow recommendations carried through to Reach 7 so as to maintain connectivity between estuary and reaches upstream.
			Dry	Not expected, but let it occur naturally.				

[1] Channel Maintenance flows could occur at any time (in Summer also).

Appendix D. Additional information to support changes in Reach 2 low flow recommendations

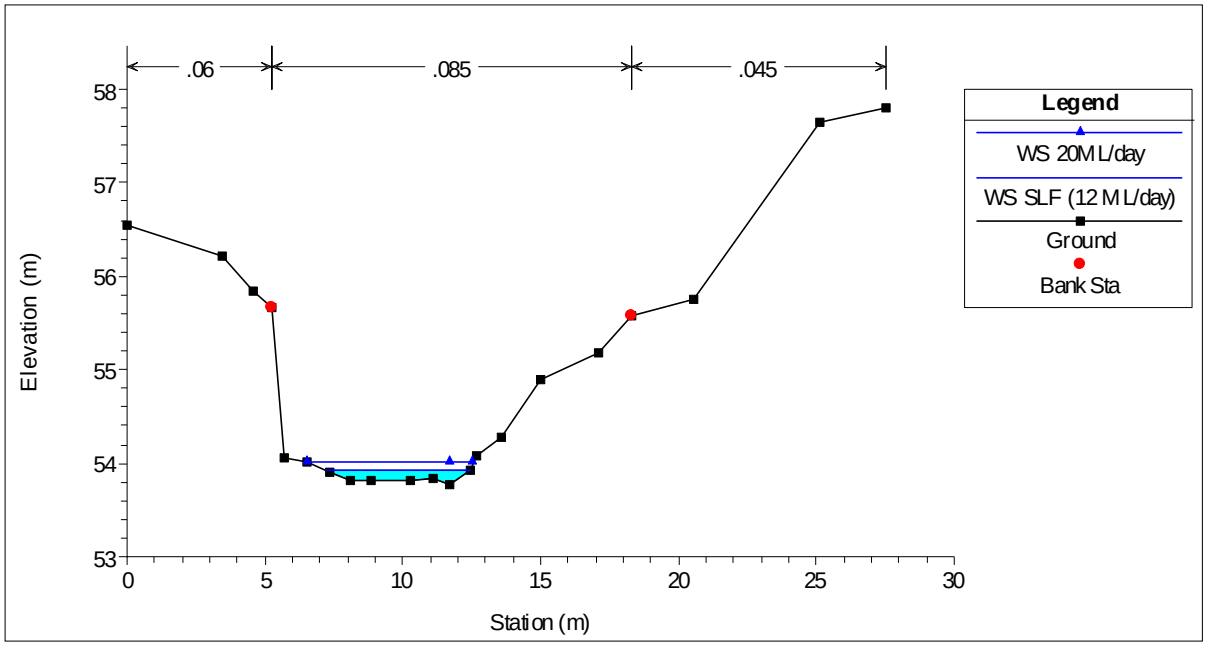


Figure D.1 : Plot showing increase in width of wetted bed/riffle and flow depth that would result with an increased in volume of recommended low flow from 12 ML/Day to 20 ML/day at Reach 2 Flows Assessment Site. Width of wetted bed/riffle increased from 5 m to 6 m and depth of flow increased from 10-15 cm to 15-20 cm.

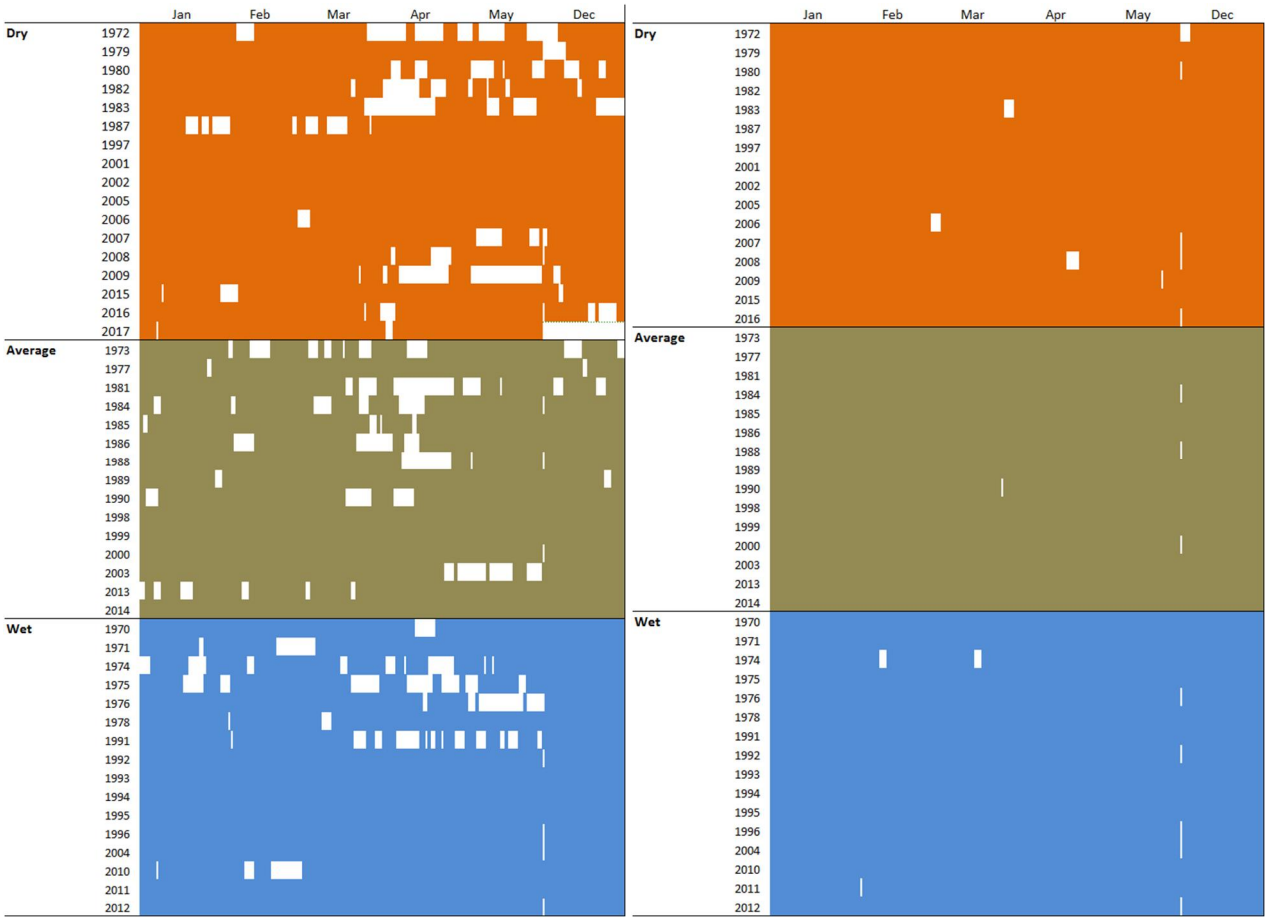


Figure D.2 : Spells analysis for Reach 2 Summer / Autumn low flow recommendation, existing 12 ML/day: current (left) and natural (right).

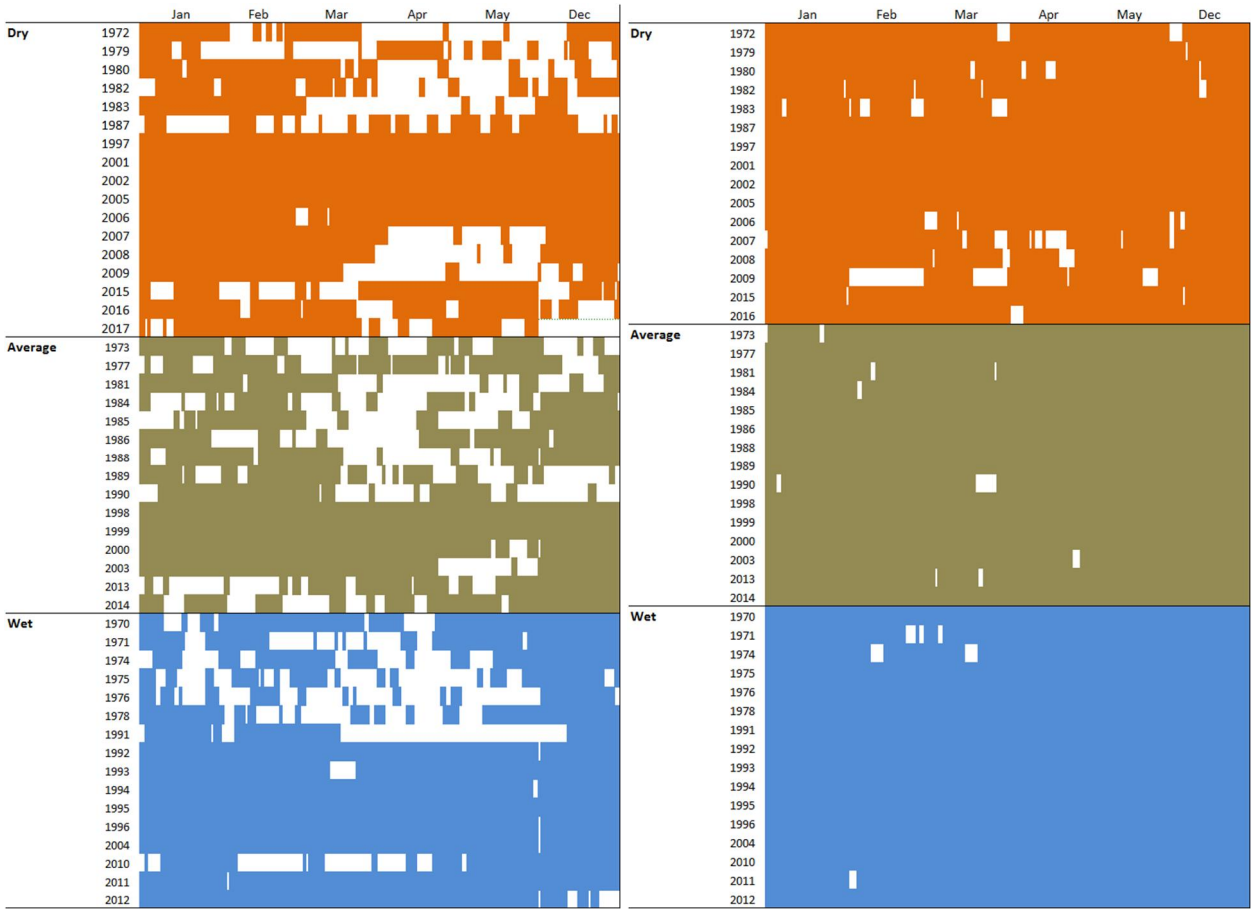


Figure D.3 : Spells analysis for Reach 2 Summer / Autumn low flow recommendation, revised >20 ML/day: current (left) and natural (right).

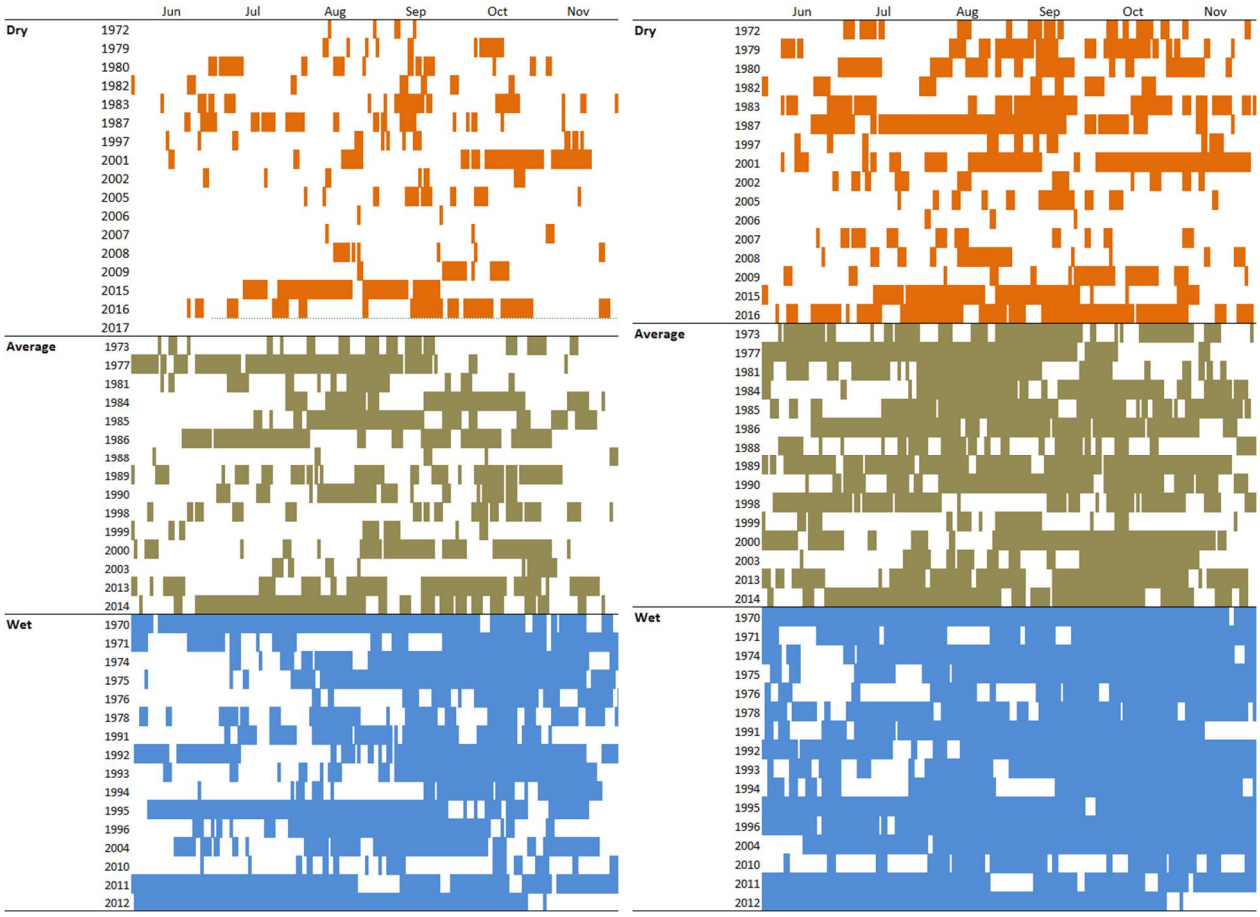


Figure D.4 : Spells analysis for Reach 2 Winter / Spring low flow recommendation, existing 100 ML/day: current (left) and natural (right) and revised 75 ML/day.

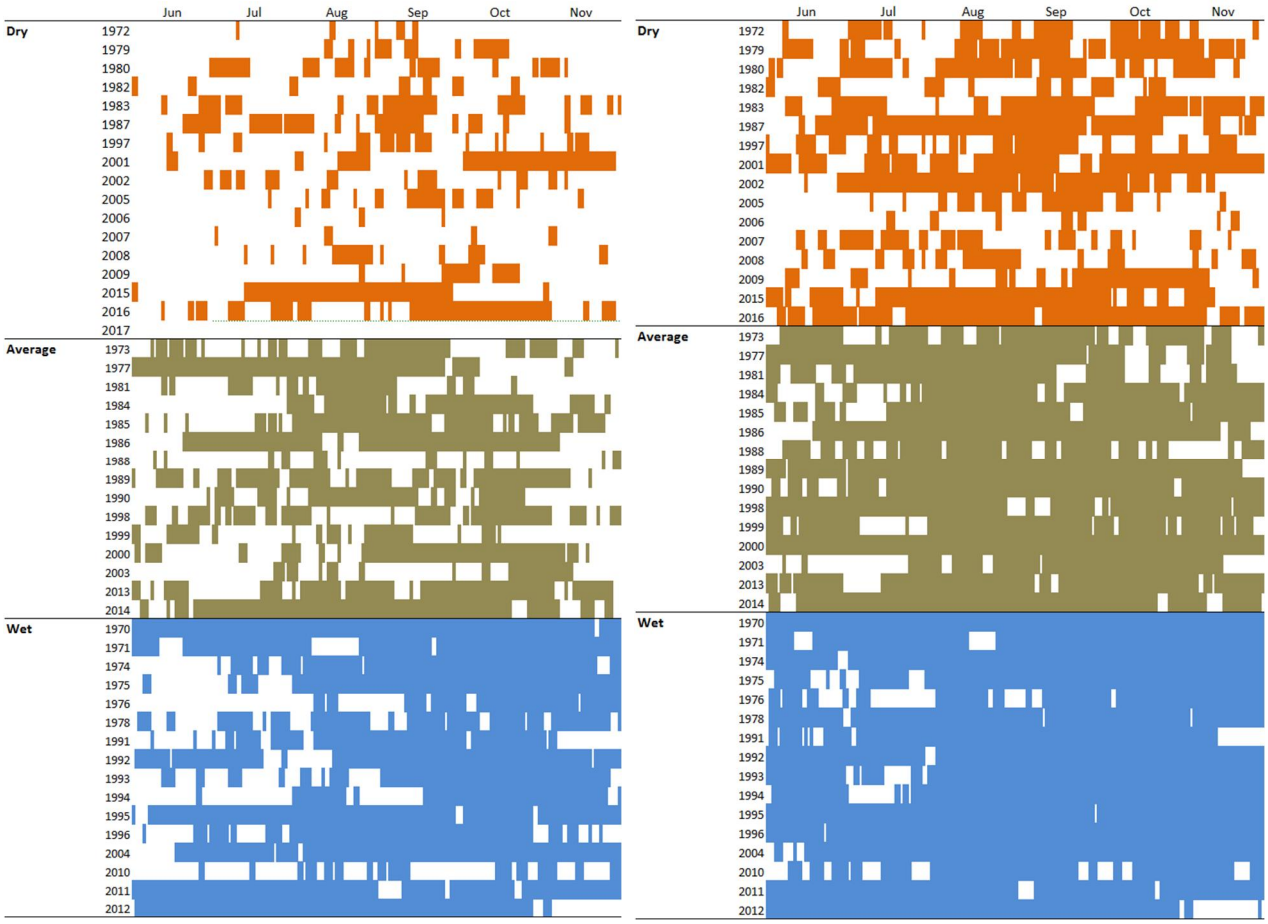
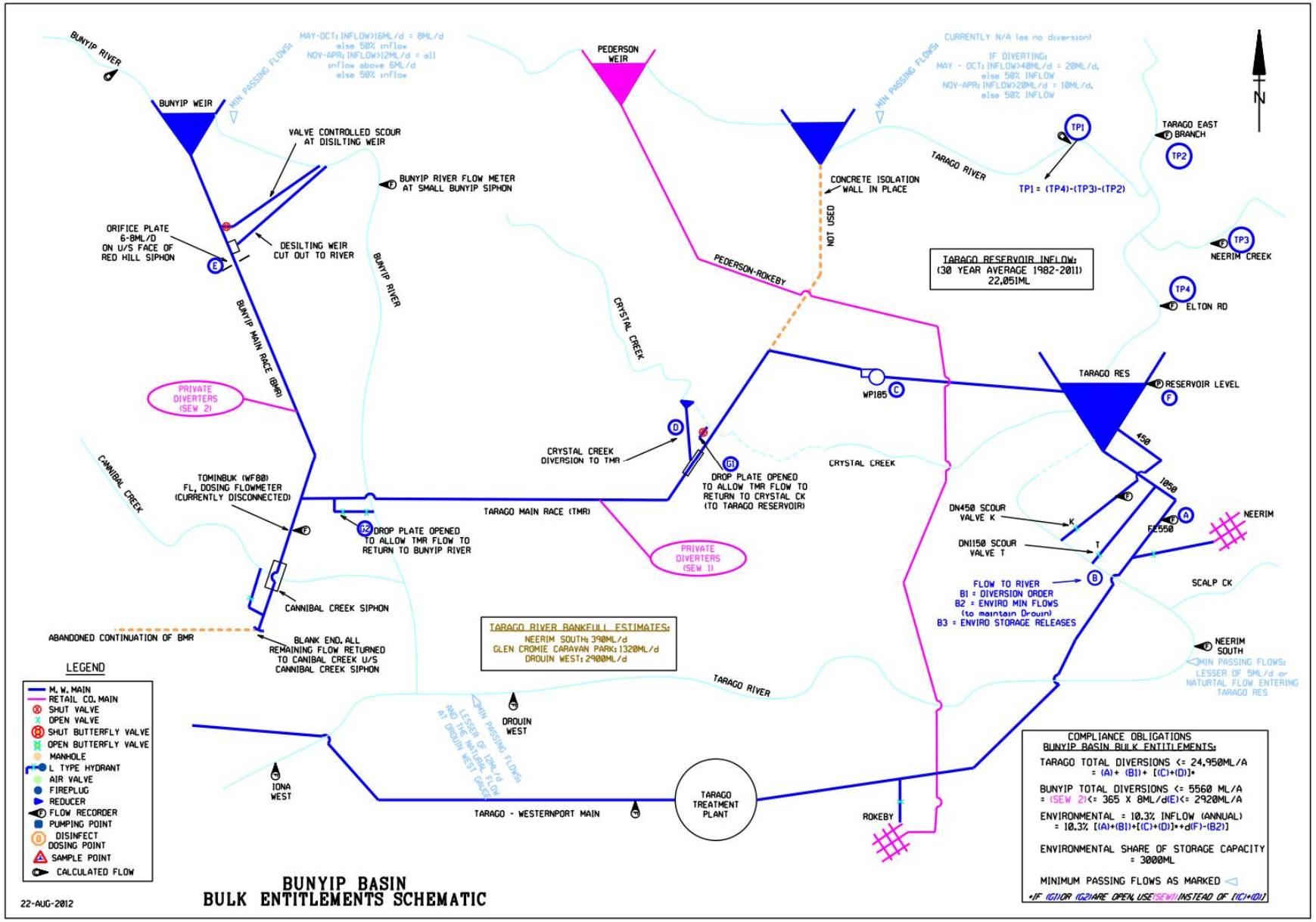


Figure D.5 : Spells analysis for Reach 2 Winter / Spring low flow recommendation, revised 75 ML/day: current (left) and natural (right).

Appendix E. Bunyip Basin Plan


BUNYIP RIVER
BUNYIP WEIR
MIN PASSING FLOWS:
MAY-OCT: INFLOW>16ML/d = 8ML/d
else 50% inflow
NOV-APR: INFLOW>12ML/d = all
inflow above 6ML/d
else 50% inflow
VALVE CONTROLLED SCOUR AT DISILTING WEIR
BUNYIP RIVER FLOW METER AT SMALL BUNYIP SIPHON
ORIFICE PLATE 6-8ML/D ON U/S FACE OF RED HILL SIPHON
DESILTING WEIR CUT OUT TO RIVER
BUNYIP MAIN RACE (BMR)
PRIVATE DIVERTERS (SEW 2)
CANNIBAL CREEK
TOMINBUK (WF80) FL, DOSING FLOWMETER (CURRENTLY DISCONNECTED)
CANNIBAL CREEK SIPHON
ABANDONED CONTINUATION OF BMR
BLANK END. ALL REMAINING FLOW RETURNED TO CANIBAL CREEK U/S CANNIBAL CREEK SIPHON
PEDERSON WEIR
CRYSTAL CREEK
CRYSTAL CREEK DIVERSION TO TMR
DROP PLATE OPENED TO ALLOW TMR FLOW TO RETURN TO BUNYIP RIVER
TARAGO MAIN RACE (TMR)
DROP PLATE OPENED TO ALLOW TMR FLOW TO RETURN TO CRYSTAL CK (TO TARAGO RESERVOIR)
PRIVATE DIVERTERS (SEW 1)
PEDERSON-ROKEBY
NOT USED
CONCRETE ISOLATION WALL IN PLACE
WP185
CURRENTLY N/A (as no diversion)
IF DIVERTING:
MAY - OCT: INFLOW>40ML/d = 20ML/d,
else 50% INFLOW
NOV-APR: INFLOW>20ML/d = 10ML/d,
else 50% INFLOW
TARAGO RIVER
TP1
TP1 = (TP4)-(TP3)-(TP2)
TARAGO EAST BRANCH
TP2
TP3
NEERIM CREEK
TP4
ELTON RD
TARAGO RESERVOIR INFLOW:
(30 YEAR AVERAGE 1982-2011)
22,051ML
TARAGO RES
RESERVOIR LEVEL
450
1050
DN450 SCOUR VALVE K
DN1150 SCOUR VALVE T
FE550
NEERIM
SCALP CK
FLOW TO RIVER
B1 = DIVERSION ORDER
B2 = ENVIRO MIN FLOWS (to maintain Drouin)
B3 = ENVIRO STORAGE RELEASES
TARAGO RIVER BANKFULL ESTIMATES:
NEERIM SOUTH: 390ML/d
GLEN CROMIE CARAVAN PARK: 1320ML/d
DROUIN WEST: 2900ML/d
TARAGO RIVER
DROUIN WEST
MIN PASSING FLOWS: LESSER OF 12ML/d AND THE NATURAL FLOW AT DROUIN WEST GAUGE
IONA WEST
TARAGO - WESTERNPORT MAIN
TARAGO TREATMENT PLANT
ROKEBY
NEERIM SOUTH
MIN PASSING FLOWS: LESSER OF 5ML/d or NATURAL FLOW ENTERING TARAGO RES
LEGEND
M. W. MAIN
RETAIL CO. MAIN
SHUT VALVE
OPEN VALVE
SHUT BUTTERFLY VALVE
OPEN BUTTERFLY VALVE
MANHOLE
L TYPE HYDRANT
AIR VALVE
FIREPLUG
REDUCER
FLOW RECORDER
PUMPING POINT
DISINFECT DOSING POINT
SAMPLE POINT
CALCULATED FLOW
COMPLIANCE OBLIGATIONS
BUNYIP BASIN BULK ENTITLEMENTS:
TARAGO TOTAL DIVERSIONS <= 24,950ML/A
= (A)+ (B1)+ [(C)+(D)]*
BUNYIP TOTAL DIVERSIONS <= 5560 ML/A
= (SEW 2)<= 365 X 8ML/d(E)<= 2920ML/A
ENVIRONMENTAL = 10.3% INFLOW (ANNUAL)
= 10.3% [(A)+(B1)+[(C)+(D)]*+d(F)-(B2)]
ENVIRONMENTAL SHARE OF STORAGE CAPACITY
= 3000ML
MINIMUM PASSING FLOWS AS MARKED
*IF (G1)OR (G2)ARE OPEN, USE(SEW1)INSTEAD OF [(C)+(D)]
22-AUG-2012
BUNYIP BASIN
BULK ENTITLEMENTS SCHEMATIC