Department of Science, Information Technology, Innovation and the Arts

Review of Water Resource (Burnett Basin) Plan 2000 and Resource Operations Plan

Appendix C–Assessment of existing environmental management rules

April 2013

Great state. Great opportunity.

Queensland Government

Prepared by

Water Planning and Coastal Sciences
Science Delivery Division
Department of Science, Information Technology, Innovation and the Arts
PO Box 5078
Brisbane QLD 4001

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Preface

This report is part of a suite of documents contributing to the environmental assessment for the Burnett Basin Water Resource Plan (WRP) review. These reports have been prepared by the Department of Natural Resources (DNRM) and Department of Science, Information Technology, Innovation and the Arts (DSITIA).

The objective of these reports is to provide an environmental assessment of the key flow-related surface water and groundwater dependent ecosystems of the Burnett Basin. A key aim is to identify environmental risks associated with a range of potential water allocation and management scenarios. Management recommendations will address these risks and propose strategies to protect the ecological values of the plan area.

The outcome of the project is presented in the following stages:

Environmental assessment report

Appendix A—Assessment of critical water requirements for selected ecological assets

Appendix B—Risk assessment for selected ecological assets

Appendix C—Assessment of existing environmental management rules

Appendix D—Assessment of groundwater-dependent ecosystem reporting nodes in the Coastal Burnett Groundwater Management Area

Appendix E—Assessment of alternative environmental management rules

Appendix F—Related planning processes

Appendix G—Response to independent science review

Executive Summary

An assessment of the existing Burnett Basin Resource Operations Plan (ROP) environmental management rules was undertaken as part of the Burnett Basin Water Resource Plan (WRP) review and subsequent ROP. This assessment found that rules that were overly quantitative and prescriptive encountered difficulties due to the inherent variability of river flows in this catchment. This was evident in ROP rules such as the variable nominal operating levels in the Bucca Weir, and the stability rule in Ned Churchward Weir. In addition, many infrastructure release rules were found to be intimately tied to environmental flow objectives (EFO) rather than a specific ecological intent. Therefore although these rules may serve an ecological purpose, their design was primarily a result of modelling assessment, not an ecological issue. Identification of specific ecological purposes for these flows may serve in their refinement, and future monitoring requirements.

Monitoring highlighted that although the ecological intent of particular rules was sound, the implementation of the rule could be better served through alternative management. This was most evident in the Bucca Weir 'medium to high flow' rule. Development of rules for the new WRP should mirror strategies within the water resource plan and be closely linked to targeted ecological outcomes.

1 Introduction

Environmental management rules, stated in the ROP, are the day-to-day implementation of some WRP strategies to achieve the WRPs ecological outcomes. This report analyses data from various sources to provide an ecological assessment of the effectiveness of the existing environmental management rules in aligning with the intent of WRP strategies, and therefore WRP ecological outcomes. In addition, some rules not distinctively categorised as environmental management rules, such as nominal operating levels, rate of release and water quality, were assessed where they have implications for environmental needs. For example, nominal operating levels are important as these are set levels in storages which should be maintained; highly relevant when accessing the influence of this rule on fishway operations.

Environmental management rules are usually specific to individual locations, particularly pieces of water infrastructure, within water supply schemes and water management areas. Therefore, this report reflects the structure of the ROP by assessing the existing environmental management rules by water supply scheme or water management area. For example, Chapter 3 assesses the existing environmental management rules within the Bundaberg Water Supply Scheme.

Some areas within the Burnett Basin are yet to be included in the ROP, such as the Three Moon Creek Water Supply Scheme and the Elliott, Gregory and Isis River catchments. The existing environmental management approaches within these areas are discussed in Chapters 6 and 7 respectively.

This reports' assessments will support recommendations to refine particular existing environmental management rules, or establish new environmental management rules that are better suited to meeting the ecological intent of the WRP. Subsequently, a review of WRP strategies and ecological outcomes may also be required to ensure they continue to serve the needs of aquatic ecosystems in the Burnett Basin.

The period of assessment for the majority of the report is from 2003 to 2009 as the ROP was implemented in 2003. In some water supply schemes and management areas, the assessment period may be different as these areas were not included in the ROP until later (for example the Boyne Tarong Water Supply Scheme ROP rules were only implemented in 2007). In other cases, some areas have yet to be added to the ROP (such as the Three Moon Creek Water Supply Scheme) and hence the assessment is based on their interim rules.

2 Bundaberg Water Supply Scheme

The Bundaberg Water Supply Scheme (BWSS) includes a number of large instream water storages such as Paradise Dam and Fred Haigh Dam, and extends across the lower Burnett and Kolan River systems (see ROP Chapter 9 Map B). Numerous environmental management rules operate in the BWSS based primarily on infrastructure releases and maintenance of particular storage water levels. The BWSS was originally included in the ROP in 2003 with an amendment in 2005 to add in the operation of the newly constructed Paradise Dam.

The following sections reflect the order that the BWSS environmental management rules are stated in ROP Attachment 4.1E.

2.1 Nominal Operating Levels of Storages (ROP Attachment 4.1E Section 1.1)

"The water level in a given storage must be maintained above that storage's nominal operating level by releasing water from the upstream storage. The operator is permitted to draw down below these levels for up to seven days per month for operational reasons such as to allow for upstream releases to reach the storage or in unseasonal conditions."

Table 1 lists the nominal operating levels (NOL) for the BWSS.

Table 1: NOL (m AHD) for Bucca Weir, Kolan Barrage, Ned Churchward Weir and Ben Anderson Barrage

Storage	Bucca Weir	Kolan Barrage	Ned Churchward Weir	Ben Anderson Barrage
January	15.32	2	13	1
February	13.57	2	13	1
March	13.57	2	13	1
April	12.2	2	13	1
May	12.2	2	13	1
June	12.2	2	13	1
July	12.2	2	13[1]	1
August	12.2	2	13[1]	1
September	12.2	2	13[1]	1
October	12.2	2	13[1]	1
November	13.57	2	13	1
December	15.32	2	13	1

[1] *Storage level should be maintained above 13m AHD for fishway operation, but the Ned Churchward Weir operation rules (see Section 2.3 of this report) take precedence over these levels*

This rule relates to ecological outcomes (EO) 6(e)(ii), 7(b), 7(d), 7(e), 13(a) and 13(b) and strategies 25 and 26 of the WRP as the rule is associated with riverine and estuarine processes, connectivity, fish movement and maintenance of pool habitats. However, the NOL were primarily set to meet environmental flow objectives (EFO). Note that NOL are closely linked with fishway operation which is discussed in Section 2.10 to 2.13 of this report.

2.1.1 Implementation

Kolan River (Bucca Weir and Kolan Barrage)

The Bucca Weir (Figure 1) and Kolan Barrage NOLs have been maintained in the majority of months. Note, in 2006 the Bucca Weir NOL was adjusted following a SunWater submission. In late 2007, critical water supply arrangements ceased the supply of water to the Bucca Weir and Kolan Barrage.

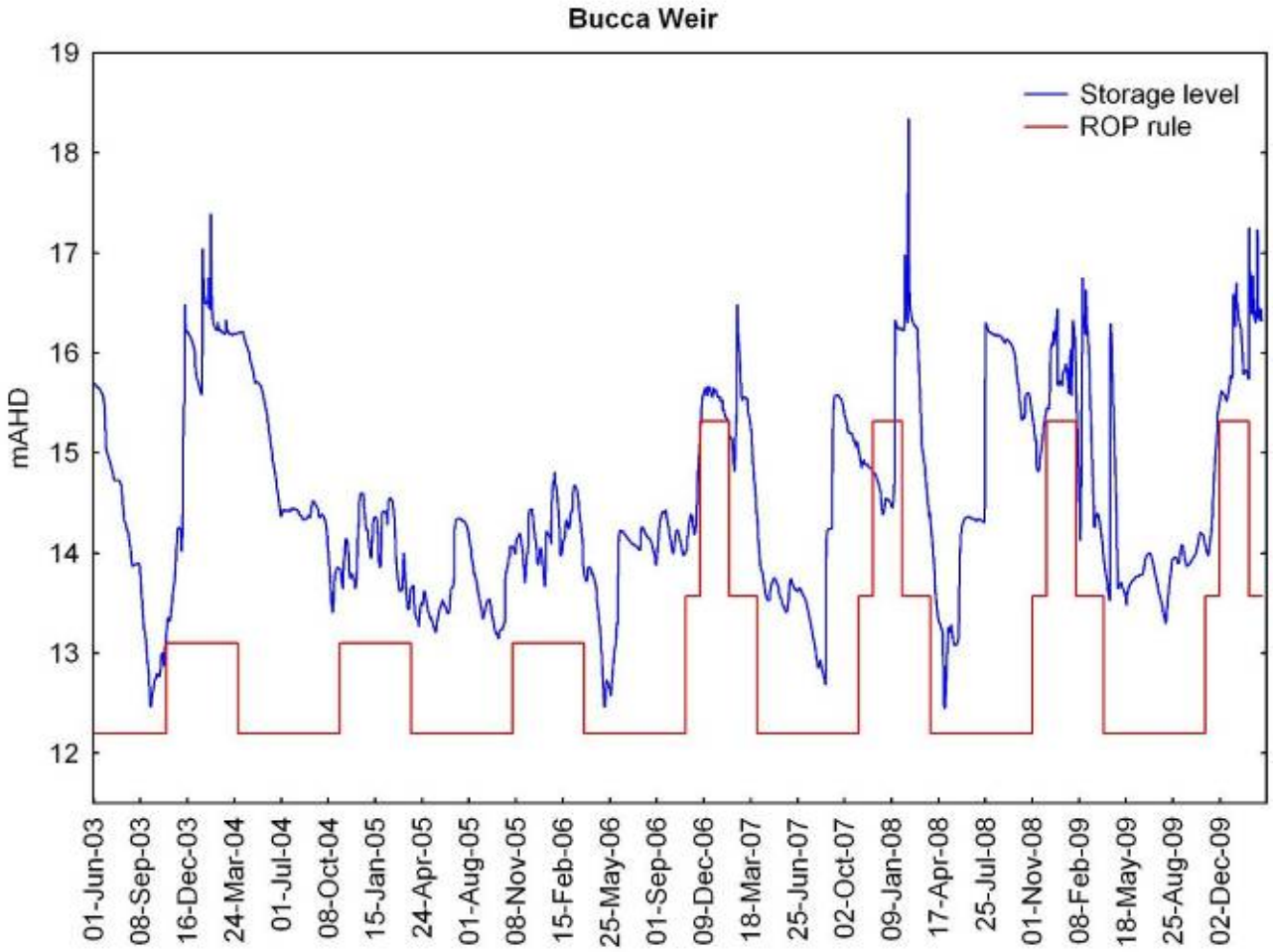

Figure 1: Bucca Weir level and required NOL for 2003 to 2009

Burnett River (Ned Churchward Weir and Ben Anderson Barrage)

The required Ned Churchward Weir NOL was always maintained above the required level. The Ned Churchward Weir NOL as related to the stability rule is further discussed in Section 2.3 of this report.

The required Ben Anderson Barrage NOL was always maintained.

2.1.2 Summary of monitoring or assessment

Sunwater reporting data is the only monitoring associated with this rule.

2.1.3 Ecological effectiveness

Kolan River (Bucca Weir and Kolan Barrage)

The ecological effectiveness of this rule, in meeting EO 13, is most notable on inspection of the brackish habitat in the Kolan River estuary (see Implementation Review Report Appendix A Section 4.5.1). The November to March staged height increase, together with the medium to high flow release strategy, facilitates more frequent spilling of Bucca Weir, contributing fresh water flows to the estuary to meet the mean wet season flow EFO. These flows are important for mangrove seedling establishment, and prawn, sea mullet and barramundi growth and recruitment.

In addition, as the Kolan Barrage NOL is set above the fishway inlet level, the fishway operated nearly 100% of the time – facilitating fish movement (see Section 2.12 of this report).

Burnett River (Ned Churchward Weir and Ben Anderson Barrage)

The Ned Churchward Weir NOL is 0.5 m below the lower entrance level of the fishway (13.5m AHD) (Andrew Berghuis, DEEDI, pers comm., 2011) - significantly restricting the operation of the fishway. In addition, the stable water level rule (July to October) requires the storage level to be maintained at the 1st July level – overriding any specified NOL and was found to be ineffective at providing macrophyte habitat (See Section 2.3). Since the ROP commenced the Ned Churchward Weir water levels have always been above the NOL.

The Ben Anderson Barrage NOL has increased the risk of White-throated snapping turtle (*Elseya albagula*) nest inundation, reduced freshwater flows to the estuary and affects the operation of the fishway (Environmental Assessment Report Appendix B). With an inlet at 1.8m AHD, the fishway only operates approximately 50% of the time (see Section 2.11 of this report).

2.1.4 Recommendations

Kolan River (Bucca Weir and Kolan Barrage)

The intent of this rule, to contribute to riverine and estuarine processes, connectivity, fish movement and maintenance of pool habitats, should be maintained. However, the ecological effectiveness of the Bucca Weir NOL should be improved by extending the higher NOL into spring to align with estuary flow requirements. Further refinement of medium to high flow release strategies out of Fred Haigh Dam and Bucca Weir should also be considered to improve the transmission of flow to the estuary (see Section 2.7 and Section 2.8 of this report).

The Kolan Barrage NOL should continue unchanged.

Burnett River (Ned Churchward Weir and Ben Anderson Barrage)

Raise the Ned Churchward Weir NOL to 13.5 m AHD to match the lower entrance level of the fishway and remove stable water level rule (discussed in Section 2.3)

The Ben Anderson Barrage NOL should be raised to at least 2.2m AHD to provide for fishway operation (see Section 2.11 of this report). In addition, a seasonally higher NOL of 3m AHD from May to July would reduce the risk of *Elseya albagula* nest inundation (Environmental Assessment Report Appendix B, Section 4.4). These higher NOLs would also allow for increased natural flows to the estuary and also improved transmission of environmental releases – providing for brackish habitat.

Table 2: Summary of BWSS NOL of storages assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Storage NOL	6(e)(ii) 7(b) 7(d) 7(e) 13(a) 13(b) NOL can be linked to riverine and estuarine processes, connectivity, fish movement, maintenance of pool habitats.	ML ML SL SL WL SL	25 26 NOL primarily set to meet EFO.	L L	++ NOL were maintained in the vast majority of months.	Bucca Weir seasonal NOL provides for increased spilling to meet the mean wet season flow EFO.	Change season and height of NOL to provide for more flows to estuary - improving ecological effectiveness of rule.
						Kolan Barrage NOL set above fishway inlet level so fishway operates nearly 100% of the time.	Continue unchanged
						Current Ned Churchward Weir NOL is 0.5 m below fishway entrance. Stable water level rule overrides NOL and ineffective. Water level always maintained above NOL level since the ROP began.	Raise NOL to 13.5 m to match fishway entrance
						Ben Anderson Barrage NOL is set below fishway inlet (1.8m AHD) so fishway only operates approximately 50% of the time.	Raise NOL to improve fishway operation, minimise *Elseya albagula* nest inundation and improve flows to estuary.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.2 Rate of release (ROP Attachment 4.1E Section 2.3)

"The ROL holder must minimise the occurrence of adverse environmental impacts (e.g. fish stranding and bank slumping) by ensuring that any change in the rate of release of water from storages occurs incrementally."

This rule relates to EO 7(c), 7(e), 11(2) and 13(a) and strategy 26 of the WRP. The intent of this rule is to ensure that storage releases are controlled to minimise the risk of adverse environmental impacts (i.e. bank slumping, fish stranding and excessive scouring).

2.2.1 Implementation

An earlier version of the ROP required SunWater to apply to the chief executive for the approval of the maximum rate of release through the outlet works within 12 months of the commencement of the ROP. SunWater subsequently submitted these release rates, which are based on the ability to turn on and off releases within one day.

2.2.2 Summary of monitoring or assessment

No fish stranding or bank slumping incidents were reported in SunWater's Annual Reports, from 2006 to 2010, downstream of any storage in the BWSS. In contrast, there were a number of instances of fish kills downstream of Bucca Weir (Kolan River) thought to be caused by extended periods of no releases. These periods of no flow occurred after sustained releases had provided ideal growing conditions for macrophytes. The sudden change of flow regime caused macrophytes to be rapidly exposed to desiccation resulting in higher biological oxygen demand on the remaining water and a subsequent acute drop in dissolved oxygen levels (See Implementation Review Report Appendix A).

An assessment of the gauged streamflow downstream of infrastructure confirmed that releases produce more frequent flow events than are found in unregulated reaches and that these releases are shut off over a shorter period of time (Figure 2). BWSS infrastructure releases (measured at Ned Churchward Weir tailwater and Figtree gauging stations) were shut down typically over a period of 2 to 5 days, whereas the recession of natural flows was on average much longer at 10 to 19 days (Auburn River and Baffle Creek). The persistence of flow events is important for water quality, food availability (macroinvertebrates) and inundation of habitat.

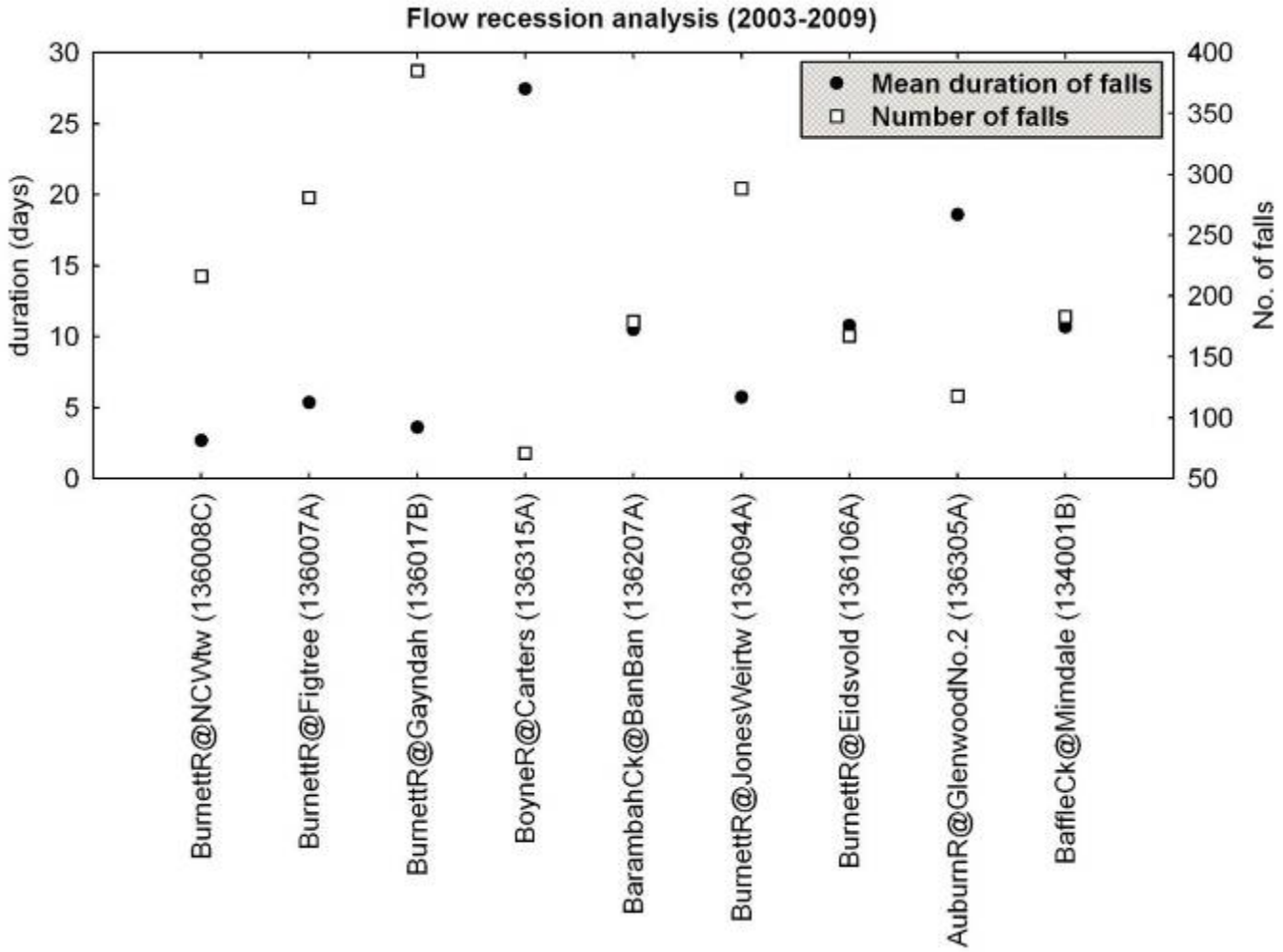

Figure 2: Flow recession analysis for various sites in the Burnett and Baffle Basins showing the effect of infrastructure. Sites progress up the catchment from left to right (excluding Mimdale) (tw=tailwater).

Monitoring has shown that the way releases are made from Ned Churchward Weir impacts downstream water temperatures. As the bulk (80%) of water released from Ned Churchward Weir, at times, is released through the gate closest to the fishway, the operator is required to extract water from lower in the water column. This is because the capacity of each gate within the release tower has a maximum capacity so more than one gate may need to be used to supply larger release volumes. These releases reduce water temperature by up to 2ºC below the ambient temperature in Spring and early Summer (Implementation Review Report Appendix A Figure 31) potentially reducing or delaying the spawning cues for a number of aquatic species.

Conducting releases in this way is an agreement between DEEDI and SunWater and is part of the Ned Churchward Weir operational manual.

2.2.3 Ecological effectiveness

There were no significant bank slumping or fish stranding events in SunWater Annual Reports between 2004 and 2010 suggesting that the rate of release procedures were not causing adverse impacts to aquatic ecosystems. However, issues such as fish kills and downstream water temperature changes suggest that infrastructure operations should be reviewed to limit these impacts.

2.2.4 Recommendations

It is recommended that the rate at which water is released for consumptive purposes better reflects natural flows. That is, instead of a constant release with a rapid rate of rise and fall at the start and end of the release, the release should incrementally reduce over a number of days to more closely mimic natural events. Rapid changes in rate of release can negatively impact the ecosystem through, for example, fish kills and desiccation of lungfish eggs. It is also recommended that the department work with SunWater to establish better practices relating to changing the rate of infrastructure releases.

Table 3: Summary of BWSS Rate of Release Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximum rate of release	7(c) 7(e) 11(2) 13(a) Controlling the rate of release assists in minimising the risk of adverse environmental impacts (i.e. fish stranding, bank slumping and excessive scouring).	L SL SL L	26	L	++	No significant bank slumping or fish stranding events were reported. Potential impacts of infrastructure releases on the duration of flow events important for ecological processes such as lungfish recruitment. Persistence of flow events is important for water quality, food availability (macro-invertebrates) and inundation of habitat. Rapid fall in the release rate, particularly downstream of Paradise Dam, Ned Churchward Weir and Bucca Weir, causes rapid changes in water quality. It appears that this is a contributing factor to fish kills occurring in the lower riverine reaches of the Kolan River.	Refinement of this rule is required to mitigate these risks. This can be met by a stage reduction in rate of fall of releases.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.3 Ned Churchward Weir Operations (ROP Attachment 4.1E Section 2.4)

"The water level in Ned Churchward Weir is to be stabilised within plus or minus 0.5m of the level determined at the beginning of July as far as practicable, from early July to the end of October each year. Monitoring of existing macrophyte populations within the storage is required to be conducted to determine optimum levels."

This rule relates to EO 11(2) and strategy 26 of the WRP. The intent of the Ned Churchward Weir stable water level rule is to provide a stable habitat to allow aquatic macrophytes (e.g. *Vallisneria nana* hereafter referred to as *Vallisneria*) within the storage pond to expand and provide habitat for lungfish to spawn. SunWater monitoring of the macrophyte population is to guide changes or alterations to this rule.

2.3.1 Implementation

This rule has been successfully implemented following the release of the ROP (see Implementation Review Report Appendix A Section 5.4). Although large inflows breached the upper limits of the stable water level rule in 2005 and 2008, releases were subsequently made to return the storage level to within the rule threshold (Figure 3).

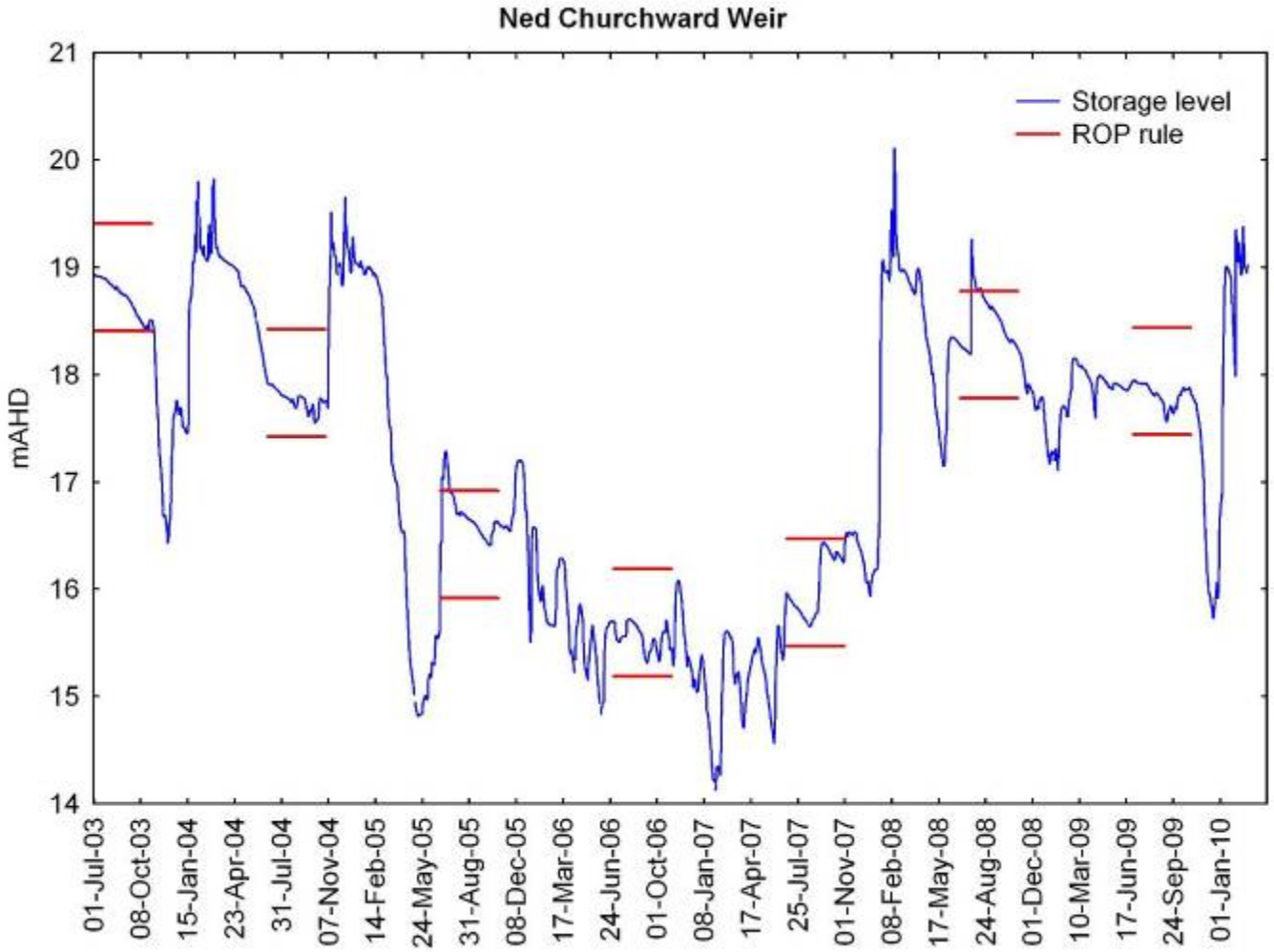

Figure 3: Ned Churchward Weir levels and stable water level rule requirement for 2003 to 2009.

2.3.2 Summary of monitoring or assessment

Initial assessments of lungfish spawning habitat in Ned Churchward Weir were conducted by the Central Queensland University between 1998 and 2001 as well as the Department of Employment, Economic Development and Innovation (DEEDI) between 1997 and 2000 (Brooks & Kind 2002, Duivenvoorden 1998a, 1998b). These studies indicated that levels in the weir should be stabilised during key periods in order to promote macrophyte growth and persistence (see Implementation Review Report Appendix A Section 4.1.2). Subsequent monitoring of water levels within the impoundment by SunWater has indicated management of this infrastructure largely succeeded in implementing this rule (see Implementation Review Report Appendix A Section 5.4). Monitoring of lungfish spawning undertaken by DERM, from 2007 to 2009, has shown spawning to primarily occur in riverine habitat (see Implementation Review Report Appendix A Section 4.1.4). In addition, more recent bathymetric surveys undertaken by DERM have highlighted the storage curve for the weir and the behaviour of water levels in the weir cause a reduction in available habitat for macrophyte growth and persistence (Section 2.3.2.2).

2.3.2.1 SunWater macrophyte data

SunWater monitored macrophytes upstream, within and downstream of Ned Churchward Weir between 1999 and 2008 and these sites align those presented in Brooks & Kind (2002). The department requested access to this data and was granted a restricted licence agreement which limits the extent that the department can publish or reproduce the information. Therefore, this data has been reviewed and a summary of the information is presented as Figure 4. The data was summarised for each site at each sampling period and *Vallisneria* extent was assessed as the percentage of transect points that contained *Vallisneria* (Duivenvoorden 2008).

SunWater monitoring showed relatively poor *Vallisneria* extent at Currajong and the Walla gauging station with very few seasons of reasonable extent observed in the impoundment. Upstream sites within the impoundment revert to riverine habitat through extended dry periods such as 2005. On most occasions, even with the stable water rule in place, there was either very limited extent measured due to the excessive slope of the impoundment banks or the sites were dry. This is in direct contrast to the consistently greater extent of *Vallisneria* observed at sites both upstream (Kalliwa) and downstream of the weir (Johnsons) (Figure 4). Unfortunately due to changes in recorders and data collection methods, there were substantial data gaps in the macrophyte presence data, negating a full analysis of the extent of key lungfish spawning habitat (>90% *Vallisneria* cover) (Brooks & Kind 2002).

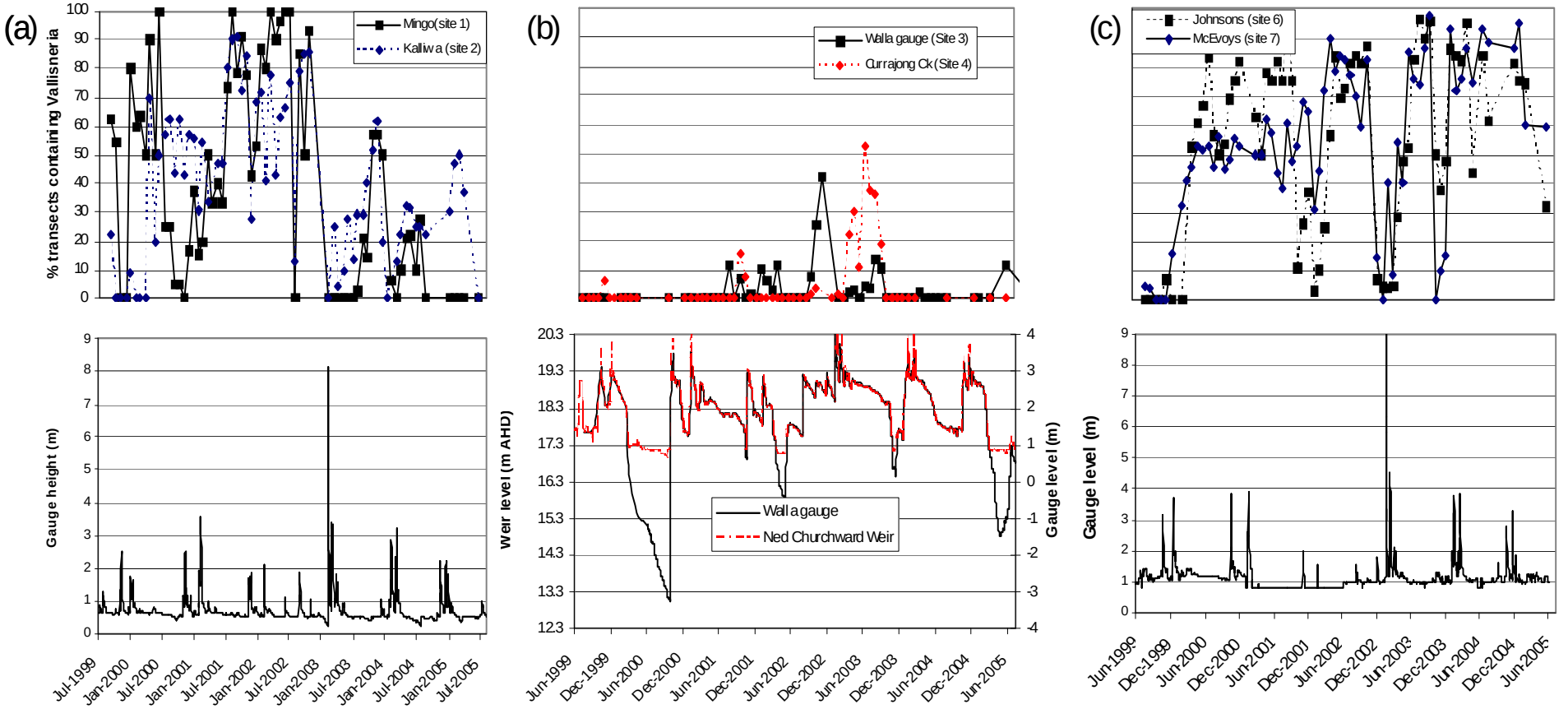

Figure 4: Relative abundance of *Vallisneria* (a) upstream, (b) within and (c) downstream of Ned Churchward Weir (summary of SunWater monitoring data).

2.3.2.2 Ned Churchward Weir mapping

Impacts on lungfish spawning requirements were assessed in Ned Churchward Weir which has a specific stable water level rule to provide macrophyte habitat (e.g. *Vallisneria*) for lungfish egg deposition. Simulated level data (BWSS Integrated Quantity Quality Model (IQQM) Case 206W) was analysed to determine the long term behaviour of Ned Churchward Weir during critical periods for lungfish spawning. Specifically, the storage elevation at the start of each water year during the simulation period was assessed to determine the occurrence of potential macrophyte habitat areas (<1 m depth). The relationship between depth and submerged macrophyte growth was based on review of scientific literature. The 1 m depth criterion was formulated through research on the spatial distribution of macrophytes in the Burnett River (Duivenvoorden 1997, 1998a, 1998b, 2008), and considered light penetration depth. The storage elevation during the simulation period was then compared with measured storage data from Ned Churchward Weir since introduction of the ROP in 2003 (see Appendix A of Implementation Review Report).

Bathymetric mapping results for Ned Churchward Weir revealed variable habitat availability for macrophyte growth depending on storage elevation (Figure 5). This result has significant implications due to management of this infrastructure currently stabilising water levels from July to October (overlapping the lungfish spawning season). Maximum potential macrophyte habitat of <1m depth throughout the impoundment, coincided with storage elevations between 15 and 16m AHD (Figure 5). The minimum of available habitat was present when the impoundment was at full storage capacity (19m AHD), and also at its NOL of 13m AHD (~63 ha).

Long reaches of riverine habitat are re-established as the storage progressively draws below its full supply level. This is important as lungfish spawning has been found to occur predominantly in riverine habitat (Brooks & Kind 2002; Espinoza et al. unpubl.). Up to 18 km of the Burnett River was found to be regained from full supply level (19m AHD) down to NOL (13 m AHD) (Figure 5), however it is not known whether the habitat conditions then provided in these reaches through storage drawdown are conducive for substantial *Vallisneria* growth and extent.

Modelling of storage behaviour through the simulation period (1890 to 1997) found that Ned Churchward Weir is more likely to be full (17 to 19m AHD) when management stabilises water levels in July of each simulated year. Very rarely is the weir below 16m AHD at July. Combining these three results it is evident that lungfish spawning rates are potentially being reduced through current management of water levels in Ned Churchward Weir.

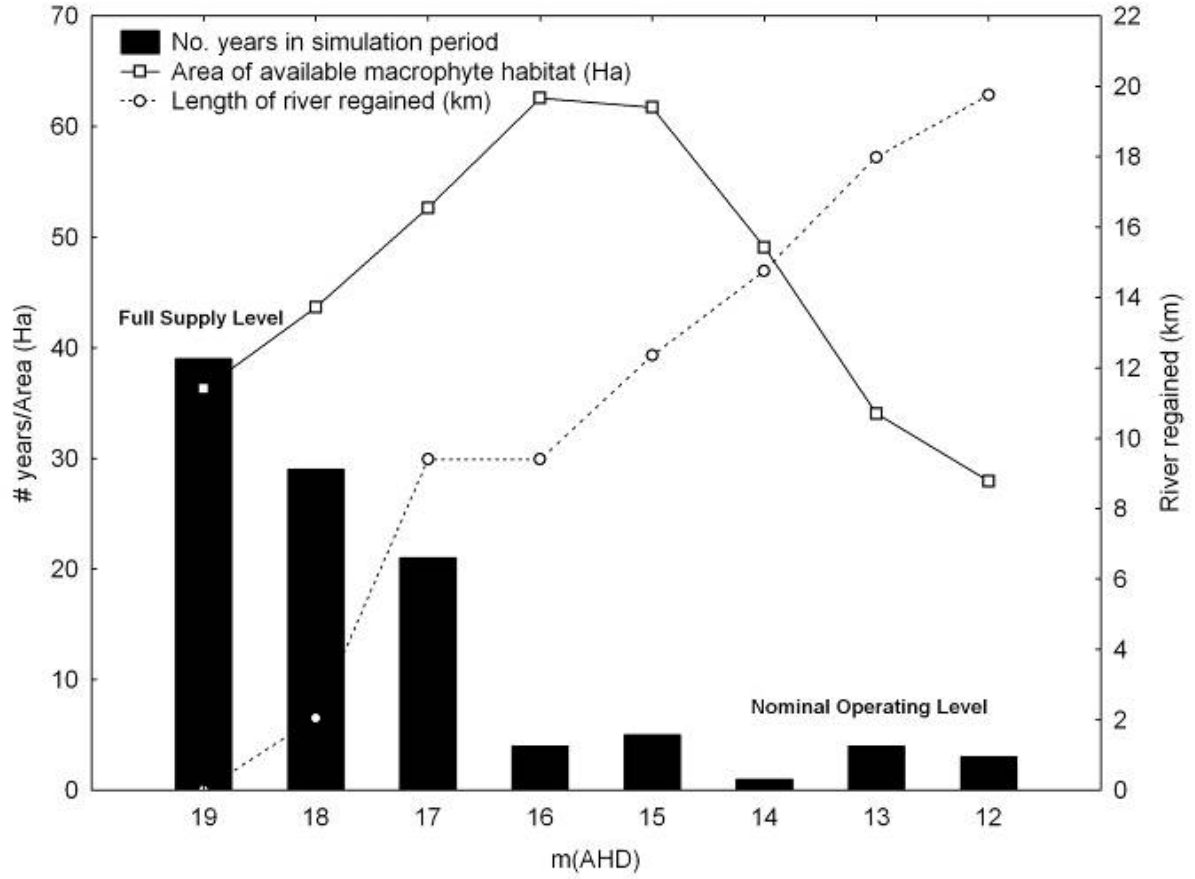

Figure 5: Modelled Ned Churchward Weir storage behaviour and riverine and potential macrophyte habitat.

2.3.3 Ecological effectiveness

The ecological effectiveness of this rule could be considered negligible as –

- recent Queensland Government monitoring showed lungfish spawning to be largely absent from impoundments, with natural riverine habitat preferred
- Preliminary evidence also suggests lungfish may spawn in response to small flow events in this riverine habitat.
- Bathymetric surveys highlight a reduced level of suitable depth gradients within the impoundment suitable for macrophyte growth, particularly when the storage is full (19 m AHD). SunWater macrophyte monitoring data demonstrates the reduced extent of dense macrophyte within the weir when compared to riverine reaches upstream and downstream (Figure 4)
- the stabilisation of the impoundment at higher elevations, which is predominantly the case on 1 July, reduces the amount of riverine habitat upstream of the impoundment
- restrictions on environmental and fishway releases may be further affecting the original intent of this rule, and the EO it reflects (11(2))
- this rule was not matched to the abundance of macrophytes within the storage as at 1st July.

2.3.4 Recommendations

This rule should be removed as it currently does not provide protection to lungfish habitat. To the contrary, the rule causes the operator to reduce water levels prior to, and after, the stable water level rule to provide for downstream entitlements and to maintain the Ben Anderson Barrage. It is recommended that an inflow/outflow type rule is included for this storage to allow transfer of small flows through the river and allow the storage to drop to the NOL to provide increased upstream riverine habitat.

Table 4: Summary of BWSS Ned Churchward Weir Operations Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Stabilise Ned Churchward Weir level ±0.5m of July level (July to October)	11(2) This rule intends to stabilise the water level to promote macrophyte habitat/growth for lungfish spawning.	SL	26	L	++ This rule has been successfully implemented. Large inflows breached the upper limits of the stable water level rule in 2005 and 2008, however, releases were subsequently made to return storage levels to within rule thresholds.	Negligible as: Lungfish spawning is largely absent from impoundments as flowing natural riverine habitat with high macrophyte density is preferred. Bathymetric surveys show lack of suitable depths for macrophyte growth Level stabilisation at higher elevations reduces the amount of riverine habitat upstream. Restricts environmental releases The requirement for this rule was not linked to available habitat at 1st July each year.	Remove rule as lungfish requirements may be better provided through an inflow/outflow environmental release rule.

[1] SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule

*[2] ++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.4 Low Flow Objectives - Bucca Weir releases (ROP Attachment 4.1E Section 2.6.1)

"For Bucca Weir the minimum passing flows (inflow ≥ 158ML/d = passflow 158ML/d) are to be made during the specified month (May only). These passing flows may be used to meet the requirements of entitlement holders."

This rule relates to EO 7(a), 7(b), 7(c), 7(e) and 13(a) and strategies 25 and 26 of the WRP. The intent of this rule is to meet the WRP EFOs, in particular the 50% daily flow for each month.

2.4.1 Implementation

Prior to 2008, this rule encountered persistent problems as a methodology for deriving storage inflows was unavailable. As such, inflow volumes prior to 2007/08 were estimated using daily storage volumes and operator estimates. Figure 6 shows the Bucca Weir inflows and releases for 2004 to 2009. Minimum passflows were not activated from 2003 to 2006; however, irrigation releases during this time may have contributed towards achieving the intent of the low flow release strategy. Minimum passflows were activated in the 2007/08 and 2008/09 water years in response to inflows greater than 158ML/d (see Implementation Review Report Appendix A Section 5.6). Note the release in response (released in early June) to the inflow at the end of May 2008 is not displayed as this graph shows May data only.

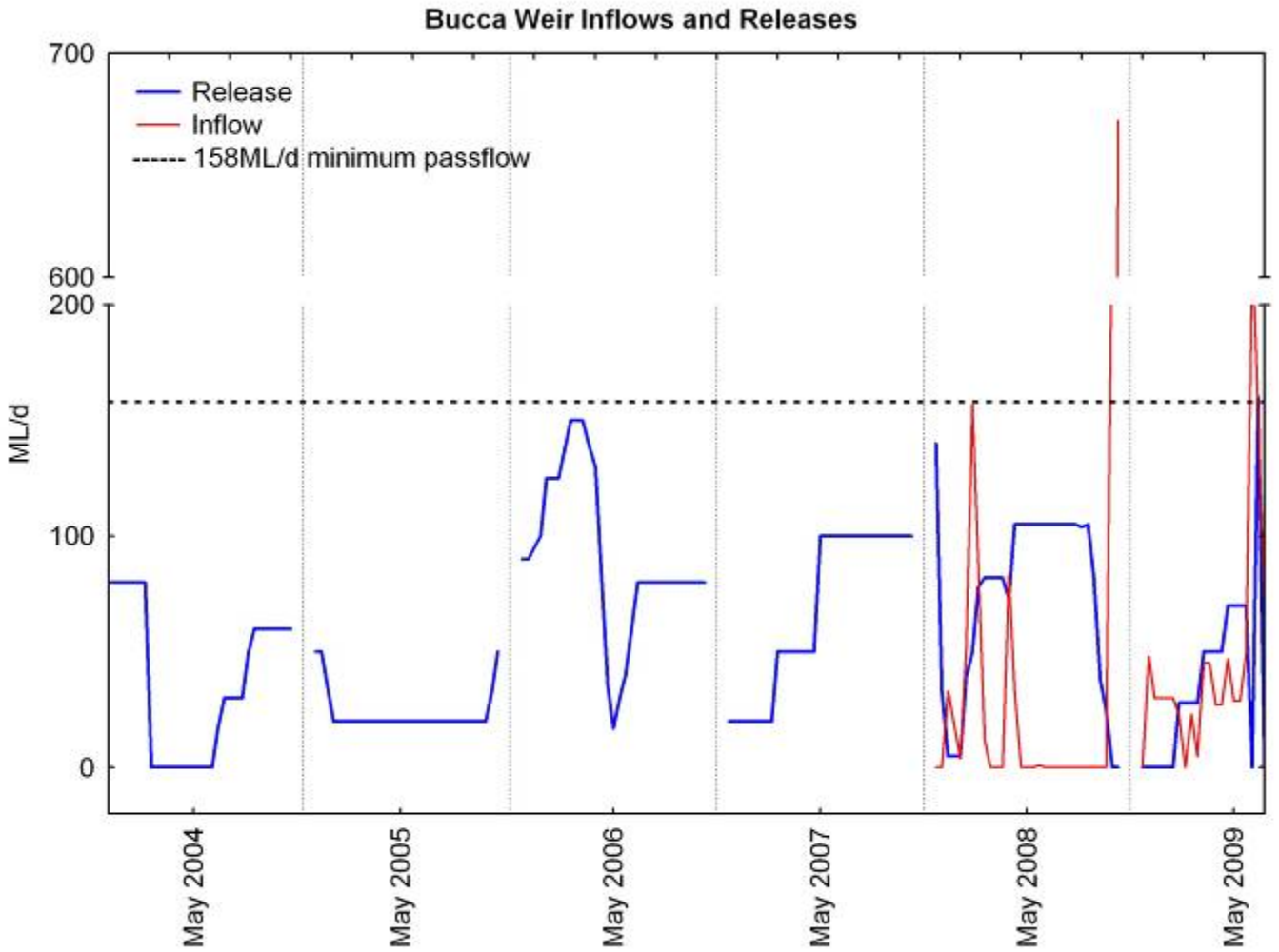

Figure 6: Bucca Weir inflows and releases during May each year between 2004 and 2009.

2.4.2 Summary of monitoring or assessment

SunWater reporting data is the only monitoring undertaken for this rule.

2.4.3 Ecological effectiveness

The BWSS Integrated Quantity Quality Model (IQQM) for the predevelopment time series at Bucca Weir suggests that daily flows of 158ML/d into Bucca Weir occur at least 50% of the time during May, between 1890 and 1997. Although the ecological intent of this flow in May is unclear, releases of these volumes are generally being made as irrigation releases and contribute somewhat towards meeting the EFO. Restricting specific low flow releases to a single month is only partially providing for environmental requirements through providing for increased discharges to the fishway on the Kolan Barrage.

Appendix B of the Implementation Review Report identified that long periods of no flow after significant persistent releases have contributed to fish kills downstream of the weir.

2.4.4 Recommendations

It is recommended that this rule is replaced with a targeted rule that provides a more natural flow regime such as an inflow/outflow rule during spring and summer.

Table 5: Summary of BWSS low flow objectives – Bucca Weir releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Bucca Weir 158ML/d (May only) releases	7(a) 7(b) 7(c) 7(e) 13(a) Rule not specifically linked to EO but is required to meet EFO.	L WL WL WL WL	25 26	L L	+ This rule activates when inflows are greater then 158 ML/d in May only. Accepted inflow derivation calculations only allowed releases from 2008.	The ecological intent of this flow in May is unclear; however these types of flows allow access for fish between the barrage and the estuary. This rule is intimately linked to EFO rather then EO.	Replace with a targeted rule that provides for a more natural flow regime, such as an inflow outflow rule during Spring and Summer.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.5 Low flow objectives - Paradise Dam releases (ROP Attachment 4.1E Section 2.6.1)

"For Paradise Dam the minimum passing flows (inflow ≥ 20ML/d = passflow 20ML/d; inflow ≥ 75ML/d = passflow 75ML/d) are to be made during the specified month (July and December respectively). These passing flows may be used to meet the requirements of entitlement holders."

This rule relates to EO 7(a), 7(b), 7(c), 7(e) and 11(2) and strategies 25 and 26 of the WRP. The intent of this rule is to meet the 90% daily flow for each month WRP EFO.

2.5.1 Implementation

Prior to 2007, this rule was not implemented due to development and approval of inflow derivation methodologies. Note, however, that sporadic irrigation releases during this time contributed somewhat to the environmental flow downstream (Figure 7). Post 2007, minimum passflows were predominately released when required with no outstanding issues (see Implementation Review Report Appendix A Section 5.3).

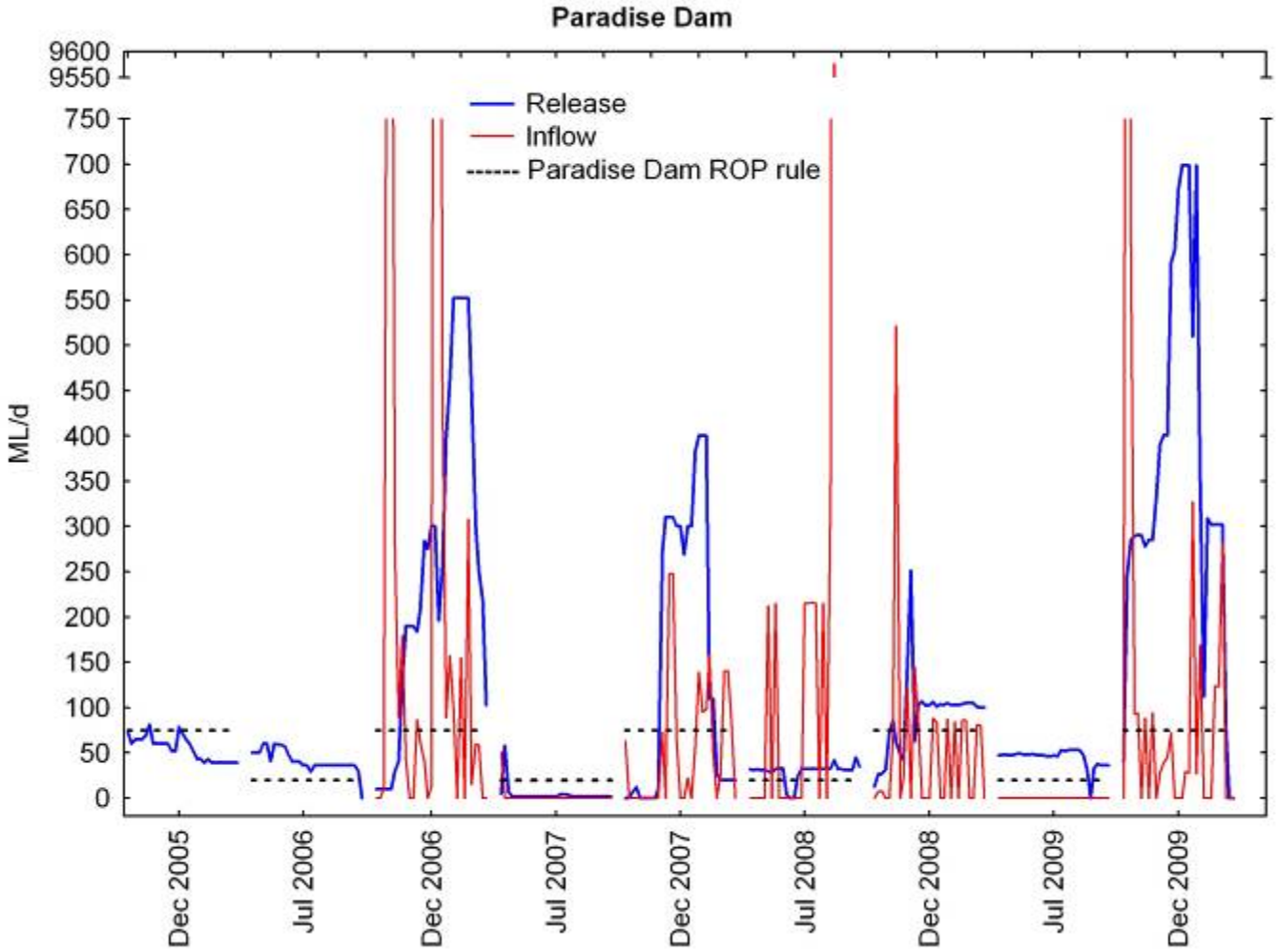

Figure 7: Paradise Dam inflows and releases during July and December between 2005 and 2009 relating to minimum passing flow rule.

2.5.2 Summary of monitoring or assessment

SunWater reporting data contributes the bulk of monitoring for this rule, however Environmental Flow Assessment Program (EFAP) lungfish monitoring occurred in this river reach and sampling occurred during these releases. Lungfish sampling revealed that the majority of spawning by lungfish occurred in October and November, and no eggs were found in the months when this rule was implemented. Whilst a discharge volume of 75 ML/d is thought to be able to provide a partial stimulus for lungfish to spawn during this time, a peak discharge ~145 ML/d was used in the risk assessment for lungfish spawning based on expert opinion (Environmental Assessment Report Appendix B).

2.5.3 Ecological effectiveness

The ecological intent of the minimum passflow rule for July and December is primarily linked to meeting the WRP EFO, however, these flows would serve to recharge downstream waterholes and maintain water quality within.

These flows are also potentially of a magnitude that may facilitate lungfish spawning and recruitment but are restricted to two months of the year - limiting their application and effectiveness.

Whilst it has been shown that the volume of flows of this magnitude downstream of Paradise Dam has not been affected substantially (see Section 2.2 of this report), the shape and duration of flows has changed. The application of these rules allow for near-real time transfer of flows through the structure to provide a closer to natural flow regime.

2.5.4 Recommendations

The intent of a rule change would be to provide a more natural flow regime to deliver on ecological outcomes such as 11(2) - which relates to maintaining lungfish habitat. Therefore, it is recommended that a minimum pass flow rule is adopted that applies to all months and is a greater magnitude to provide stimulus for fish passage and lungfish spawning. In addition, any new release rules need to align with the operation of downstream infrastructure so flows transmit through to the estuary.

Table 6: Summary of BWSS low flow objectives – Paradise Dam releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Paradise Dam 20ML/d (July) and 75ML/d (December) releases	7(a) 7(b) 7(c) 7(e) 11(2) Rule not specifically linked to EO but is required to meet EFO.	L WL WL WL WL	25 26	L L	-- Not implemented prior to 2007 due to development and approval of inflow derivation methodologies. Post 2007, minimum passflows were predominately released when required.	Ecological intent primarily linked to meeting EFO, however, flows would recharge downstream waterholes, maintain water quality within, and may facilitate lungfish spawning and recruitment.	Refine rule to provide for EO by, for example, extending to other months of the year and increasing magnitude to provide for fish passage and lungfish spawning.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.6 Low flow objectives–Ned Churchward Weir releases (ROP Attachment 4.1E Section 2.6.1)

"Whenever possible, low flow is to be provided from Ned Churchward Weir to maintain the downstream pool and riffle sequence such that the 'river health' in the pool section between Ned Churchward Weir and Ben Anderson Barrage is maintained. This is important especially during critical periods such as September and October each year during the breeding phase of aquatic insects that have an aerial phase."

This rule relates to EO 7(a), 7(b), 7(c) and strategies 25 and 26 of the WRP. The intent of this rule is to maintain the pool and riffle sequence downstream of the weir.

2.6.1 Implementation

Ned Churchward Weir release data (Figure 8) shows that the implementation of this rule has been satisfactory as a 12 ML/d flow – suitable to maintain the pool and riffle sequence – was released through the fishway for a significant proportion of time when irrigation releases were absent (see Implementation Review Report Appendix A Section 5.4).

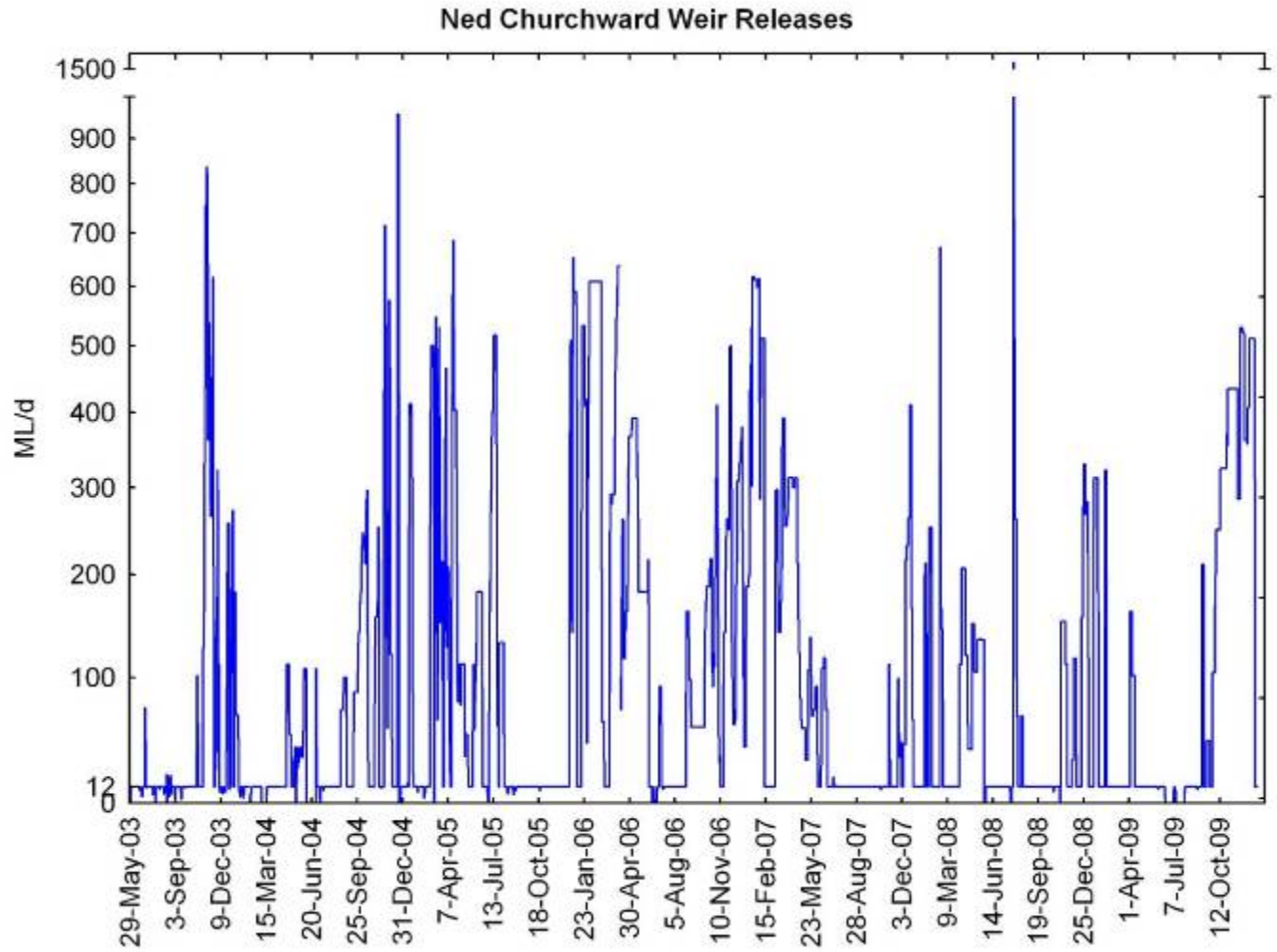

Figure 8: Ned Churchward Weir releases for 2003 to 2009 associated with low flow release rule.

2.6.2 Summary of monitoring or assessment

Monitoring associated with this rule includes SunWater reporting data, SunWater macrophyte data (discussed in Section 2.3.2.1 of this report), macro-invertebrate sampling undertaken by Ecowise Environmental in 2003 and DNRM in 2004.

The SunWater data suggests that the extent of *Vallisneria* downstream of Ned Churchward Weir is similar to that upstream of the weir, and was found to have a generally good extensive coverage at the sites throughout most of the period observed (see Figure 4 in Section 2.3.2.1 of this report).

2.6.3 Ecological effectiveness

Low flow releases from Ned Churchward Weir provide significant ecological benefits to the downstream pool and riffle sequence through providing connectivity and ecosystem services such as water oxygenation. Macro-invertebrate sampling undertaken by DERM in 2004 indicated the absence of important taxa in the riffle below Ned Churchward Weir (see Implementation Review Report Appendix A Section 3.3.2). However, sampling undertaken by Ecowise Environmental prior to this indicated these taxa to be absent both above and below the weir.

Importantly, lungfish egg sampling has documented eggs at the site not while these stable low flows are provided, but during periods after an overtopping event or after an irrigation release – indicating that Lungfish need flow variability for successful spawning. Further, it has been noted that at some sites in the Burnett River, particularly downstream of Ned Churchward Weir, that the macrophytes become covered in silt due to a lack of flushing flows (Brooks & Kind 2002).

2.6.4 Recommendations

The low flow release rule should be aligned more closely with fishway operation to provide increased ecological benefit, particularly in terms of fish passage and connectivity. In addition, it is recommended that an inflow/outflow type rule be implemented that provides variability of flows for lungfish spawning (up to 600 ML/d), fish migration stimulation and to minimise siltation of macrophytes.

Table 7: Summary of BWSS low flow objectives – Ned Churchward Weir releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Ned Churchward Weir releases for pool and riffle sequences	7(a) 7(b) 7(c)	L L L	25 26	WL WL	++ Implemented through the 12 ML/d flow provided by the fishway.	Low flow releases provide significant ecological benefits to the downstream pool and riffle sequence. This rule does not provide enough flow variability for lungfish spawning and reducing siltation.	Align more closely with principles of increasing flow variability through an inflow/outflow rule with a maximum discharge of between 200 – 600 ML/d.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.7 Medium to high flow objectives–Fred Haigh Dam releases (ROP Attachment 4.1E Section 2.6.2)

"For Fred Haigh Dam, the minimum passing flows (if Fred Haigh Dam > EL 75.14m AHD = passflow equal to previous days inflow up to 1 600ML/d) are to be made during the specified month (all months). These releases may be used to meet the requirements of entitlement holders."

This rule relates to EO 7(b), 7(c), 7(d), 7(e) and 13(a), 13(b) and 13(c) and strategies 25 and 26 of the WRP. This rule is specifically in the ROP to meet WRP EFOs.

2.7.1 Implementation

At the time of this assessment, Fred Haigh Dam had not reached the minimum threshold (EL 75.14 m AHD) since commencement of the rule therefore; implementation success is yet to be determined. However, SunWater has since advised that the maximum outlet capacity of Fred Haigh Dam is 460 ML/d (not 1600 ML/d) – therefore this rule can not be implemented successfully as written.

2.7.2 Summary of monitoring or assessment

Sunwater reporting data contributes the bulk of monitoring for this rule.

2.7.3 Ecological effectiveness

The ecological effectiveness of this rule is yet to be determined as the rule had not been implemented during the period of this assessment. A flow of the initial outlet capacity (1600 ML/d) is expected to create significant brackish habitat in the Kolan River estuary. In contrast, the revised outlet capacity is thought to only extend the time that brackish conditions prevail and not additionally add to the extent of brackish habitat.

2.7.4 Recommendations

Infrastructure operating rules for downstream infrastructure (i.e. Bucca Weir) should be aligned with this release rule to ensure any releases are transmitted through the system to the estuary. In addition, the storage level threshold should be reduced to a level that is frequently exceeded (e.g. 90% of the time).

Table 8: Summary of BWSS medium to high flow objectives – Fred Haigh Dam releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Fred Haigh Dam 1600 ML/d releases.	7(b) 7(c) 7(d) 7(e) 13(a) 13(b) 13(c) Rule not specifically linked to EO but is required to meet EFO.	L L L L L L L	25 26	L L	---- Not determined as Fred Haigh Dam had not reached the minimum threshold (EL 75.14 m AHD) during the period of assessment. However SunWater advise that maximum outlet capacity is 460 ML/d.	Not determined as the rule was not implemented during period of assessment. Pending transmission, a flow of up to 460 ML/d is expected to maintain the persistence of brackish habitat in the Kolan River estuary.	Align with downstream infrastructure so flows are transmitted to the estuary. Review the storage level threshold so the rule triggers more often.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.8 Medium to high flow objectives–Bucca Weir releases (ROP Attachment 4.1E Section 2.6.2)

From January to April, a minimum flow of 380 ML must pass Bucca Weir that day if –

- the storage level of Bucca Weir is less than EL 16.25 m AHD; and Kolan Barrage is spilling; and
- the storage in Fred Haigh Dam is greater than 53 m AHD.

This rule relates to EO 7(b), 7(c), 7(d), 7(e) and 13(a), 13(b) and 13(c) and strategies 25 and 26 of the WRP. The intent of this rule is to provide freshwater flow during the wet season to the Kolan River estuary and therefore is fundamentally linked to the WRP wet season EFO.

2.8.1 Implementation

This Bucca Weir release rule was implemented successfully in 2007, 2008 and 2009 following overtopping events at Bucca Weir (Figure 9). The main issue with this rule is that when initiated, it does not cease until the end of April (see Implementation Review Report Appendix A Section 5.6) and that the rule operates regardless of recent local rainfall/inflow. Therefore, SunWater may need to use stored water in Fred Haigh Dam and Bucca Weir to supply the 380 ML/d (potentially up to 46 000 ML if released from January to April). As the volume of this potential release can not be anticipated, this rule can impact on the delivery of announced allocation water to BWSS users by diminishing the useable volume available. This rule has therefore been quite contentious each year that it has been implemented.

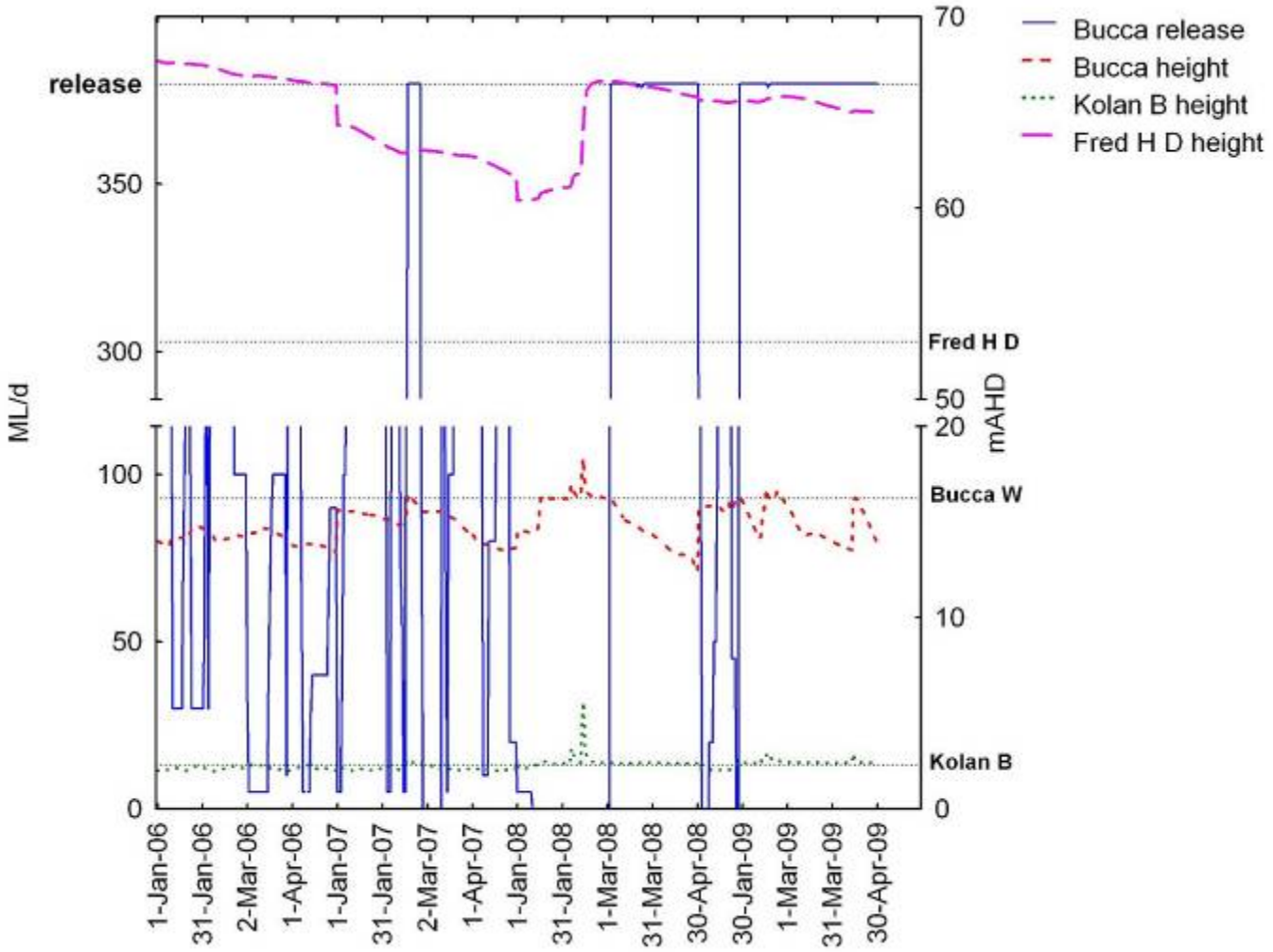

Figure 9: Releases and storage heights for 2006 to 2009 associated with Bucca Weir medium to high flow release rule. Solid horizontal lines (R) indicate minimum storage height (m AHD) thresholds for activation of 380ML/d release rule (L).

2.8.2 Summary of monitoring or assessment

Monitoring undertaken for this rule includes SunWater reporting data, DNRM's EFAP monitoring and salinity monitoring programmes which monitors of the extent of brackish water within the estuary during and after the releases. An assessment has concluded that the self perpetuating nature (feedback loops) of the rule, forces releases from Fred Haigh Dam, despite "natural" flow conditions, and results in large volumes of water passing to the Kolan River estuary over extended periods of time.

2.8.3 Ecological effectiveness

Although insufficient to extend the brackish habitat, DNRM's EFAP and salinity monitoring programs have highlighted that the 380 ML/d release from Bucca Weir provides persistence in estuarine brackish habitat (see Implementation Review Report Appendix A Section 4.5.1, and Environmental Assessment Report Appendix B Chapter 2). Specifically, the spatial extent of the brackish habitat in the Kolan River estuary is maintained for longer due to these releases, particularly in the upper estuary. In turn, this habitat is important for important estuarine species including banana prawns, sea mullet, mangroves and barramundi. However, feedback loops within this rule may be maintaining brackish habitat for longer than it would have occurred naturally over individual flow events.

2.8.4 Recommendations

Refinement of this rule should also include consideration of inflow/outflow rules for Fred Haigh Dam such that flows are passed through the system more naturally, particularly in terms of duration. An inflow/outflow rule, up to the outlet capacity of Bucca Weir, would allow a greater peak volume (1790 ML/d) to be passed which would allow extension of the brackish habitat. In addition, if based on an inflow/outflow arrangement, the releases would be dependent on inflows thus preserving the usable volume in the storages.

Table 9: Summary of the BWSS medium to high flow objectives – Bucca Weir releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Bucca Weir 380 ML/d (January to April) releases	7(b) 7(c) 7(d) 7(e) 13(a) 13(b) Rule not specifically linked to EO but is required to meet EFO.	WL WL L WL WL L	25 26	L L	++ Implemented over a number of years. Contentious rule with BWSS users.	380 ML/d release insufficient to extend estuarine brackish habitat but does provide persistence. Important for estuarine species including banana prawns, sea mullet, mangroves and barramundi. Feedback loops may be maintaining brackish habitat for longer than it would have occurred naturally.	Refinement of this rule should include development of inflow/outflow rules for Fred Haigh Dam such that flows are passed through the system more naturally, particularly in terms of duration.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.9 Medium to high flow objectives–Paradise Dam releases (ROP Attachment 4.1E Section 2.6.2)

In all months, releases from Paradise Dam must be made up to the outlet capacity of 26 000 ML/d based on a number of criteria such as inflow rate, downstream gauged flow and the storage level as stated in Table 7 of the ROP. Note, this release is only required once per year, and only if 26 000 ML/d at Figtree Gauging Station is not already achieved naturally. In addition, through August to November, inflows up to 14 000 ML must be released provided the storage level is above EL 63.45 m AHD.

This rule relates to EO 7(b), 7(c), 7(d), 7(e) and 11(1) and strategies 25 and 26 of the WRP. The intent of this rule is to ensure compliance with the 1: 1.5 year ARI and APFD (average percentage flow deviation) EFOs within the WRP. Flows of the higher magnitudes (> 10 000 ML/d) can provide significant brackish habitat in the Burnett River estuary should they pass through the downstream infrastructure. In addition, smaller magnitude flows can provide spawning conditions for lungfish and stimulus for fish migration through fishways.

2.9.1 Implementation

Since construction of Paradise Dam in 2005, this rule was only implemented in 2009 when the storage level reached 63.45 m (see Implementation Review Report Appendix A Figure 35). However, the magnitude of releases was significantly less than that specified in the ROP as the environmental release tower had not yet been fully commissioned. In 2010, there have been substantial releases made under this rule which have maintained an extensive brackish habitat in the Burnett River estuary.

2.9.2 Summary of monitoring and assessment

SunWater reporting data, and the Queensland Government's salinity monitoring program and EFAP monitoring program are associated with this rule.

2.9.3 Ecological effectiveness

As this rule has only been recently implemented, the ecological effectiveness is yet to be fully determined. Preliminary monitoring of estuarine brackish habitat, however, indicates that the volumes capable of being released from Paradise Dam are sufficient to provide significant spatial and temporal brackish habitat (discharges > 10 000 ML/d) when transmitted effectively past Ned Churchward Weir and Ben Anderson Barrage (see Implementation Review Report Appendix A Section 4.5.1 and Environmental Assessment Report Chapter 2 Appendix B). In addition, smaller releases have been associated with fish movement and lungfish spawning in riverine reaches downstream of Paradise Dam (see Implementation Review Report Appendix A).

2.9.4 Recommendations

Infrastructure operating rules for downstream infrastructure (i.e. Ned Churchward Weir and Ben Anderson Barrage) should be aligned to ensure any releases are transmitted through the system to the estuary. In addition, consideration should be given to refining the release volumes, Paradise Dam threshold levels and timing (i.e. extending this release throughout the entire year).

Table 10: Summary of the BWSS medium to high flow objectives – Paradise Dam releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Paradise Dam 14 000 ML/d (August to November) and 26 000 ML/d (all months) releases	7(b) 7(c) 7(d) 7(e) 11(1) 11(2) Rule not specifically linked to EO but is required to meet EFO.	L L L L L L	25 26	L L	+ Releases were only implemented after 2008 as Paradise Dam had not yet reached threshold storage level. Substantial release in 2010.	Preliminary monitoring of estuarine brackish habitat indicates the volumes released have created significant spatial and temporal brackish habitat in the Burnett River estuary. Smaller release volumes promote fish movement and lungfish spawning.	Review infrastructure operating rules for downstream infrastructure to ensure flows transmitted to the estuary. Consider refining the release volumes, dam threshold levels and timing to provide peak flows of >10 000 ML/d during Spring and Summer.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.10 Releases associated with fish transfer devices–Ned Churchward Weir (ROP Attachment 4.1E Section 2.8.1)

"The Ned Churchward Weir fishway must be operated when the weir storage level is between 13.5m AHD and 19m AHD and releases of greater than 14ML/day are being made or if the weir is overflowing up to a height of 20.1m AHD. The fishway may be operated at other times, such as when meeting the system operational requirements."

This rule relates to EO 7(e) and 11(2) and strategies 26 and 35 of the WRP.

2.10.1 Implementation

The fishway on Ned Churchward Weir is operational between EL13.5m and EL19 m AHD. Assuming the fishway was operated at all times when releases were ≥ 14 ML/d (as required by the ROP); fish passage was provided by the infrastructure for 42% of the time between 29 May 2003 and 31 December 2009. In reality, however, the fishway is operated for most of the year under a 12 ML/d flow which is the predominant release for downstream riverine health (see Implementation Review Report Appendix A Section 5.9 and Section 2.6 of this report). If this release volume is used, the fishway was operational for >96% of the time.

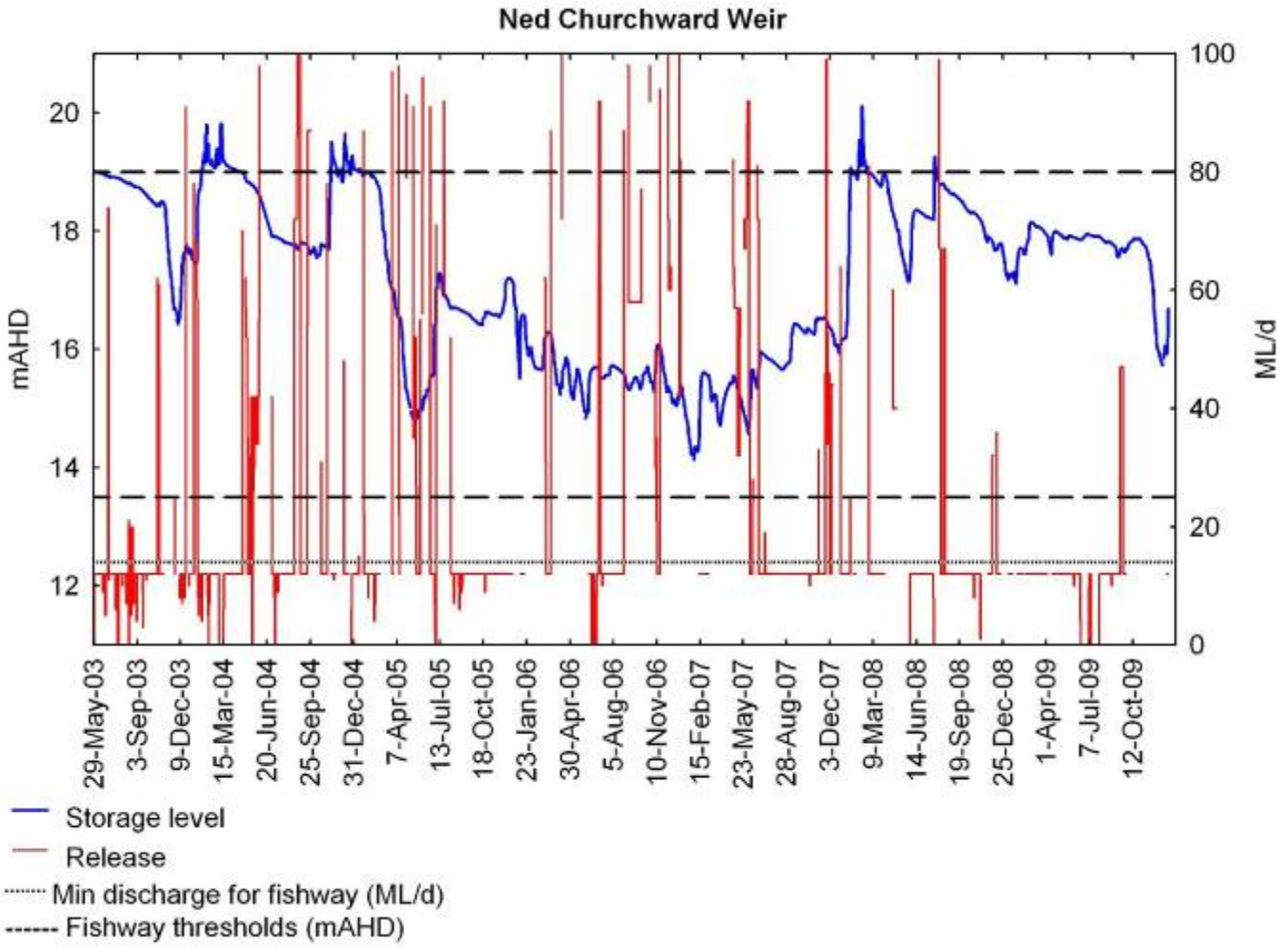

Figure 10: Ned Churchward Weir level and releases for 2003 to 2009 associated with fishway operation rule.

2.10.2 Summary of monitoring and assessment

Minimal monitoring of this rule has been undertaken by DNRM with SunWater reporting daily fishway release volumes through quarterly reporting.

2.10.3 Ecological effectiveness

The ecological effectiveness of this rule is largely subject to fishway design and operation in providing fish passage. The rule has been based on recommendations by DAFF which are based on research findings. This fishway has been shown to transfer a variety of species such as lungfish, sea mullet and fork-tailed catfish (Berghuis et al. 2000). Up to 22 species of fish have been shown to move through this fishway.

2.10.4 Recommendations

The fishway operation rule should be removed as the operation is controlled by DAFF, with DNRM supporting operation of the fishway by providing a Ned Churchward Weir NOL of 13.5 m (see Section 2.1.4 of this report). It is anticipated that a Fishway Management Plan may be established by DEEDI and implemented by SunWater.

Table 11: Summary of the BWSS releases associated with fish transfer devices – Ned Churchward Weir – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Ned Churchward Weir fishway operation	7(e) 11(2)	SL L	26 35	L L	++ Fishway operated for the majority of time.	**Fishway operated for the majority of time the ROP was in place. Up to 22 species of fish have been shown to move through this fishway.**	Remove current rule. Increase the Ned Churchward Weir NOL to 13.5 m facilitate fishway operations.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.11 Releases associated with fish transfer devices–Ben Anderson Barrage (ROP Attachment 4.1E Section 2.8.2)

"The Ben Anderson Barrage fishway must be operated when the barrage storage is between 2.2m AHD and 3.97m AHD. The releases must vary between 7ML/d when at 2.2m AHD and increase gradually to 13ML/d as water level rises to 3.97m AHD. The fishway must be fully open when the storage level is above 3.97m AHD. The fishway may be operated at other times, such as when meeting the system operating requirements."

This rule relates to EO 7(e) and strategies 26 and 35 of the WRP.

2.11.1 Implementation

Implementation of this rule is fairly straightforward as the fishway operates passively; however, fishway operation is subject to storage level which, in turn, is dictated by conditions in upstream impoundments. This was evident in 2006 and 2007 as low levels in upstream impoundments ceased the delivery of environmental flows to top-up the barrage and make the fishway operational (Figure 11). As such, the Ben Anderson Barrage fishway operated 64% of the time (see Implementation Review Report Appendix A Section 5.9) in implementing the ROP rules.

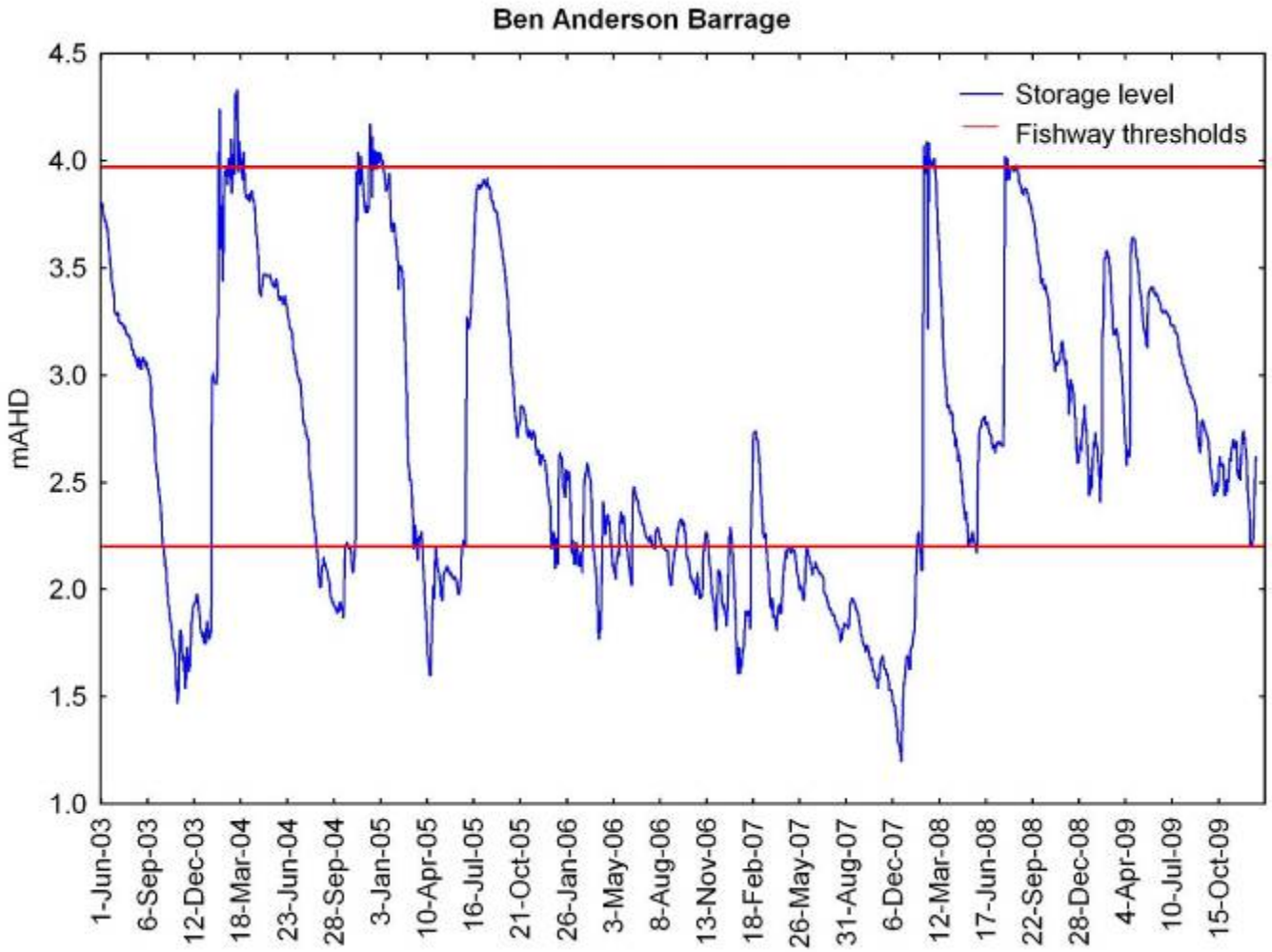

Figure 11: Ben Anderson Barrage level for 2003 to 2009 associated with fishway operation.

2.11.2 Summary of monitoring and assessment

Monitoring of this rule is mostly through SunWater reporting data.

2.11.3 Ecological effectiveness

The ecological effectiveness of this rule is intimately tied to other ROP rules (i.e. NOL) for the Ben Anderson Barrage. The fishway operated consistently when water levels were within the range of the rule; however there were periods of substantial time that the fishway did not operate due to lower water levels – reducing the effectiveness of the fishway.

2.11.4 Recommendations

The fishway operation rule should be removed as the operation is controlled by DAFF, with DNRM supporting the operation of the fishway by providing a seasonally minimum Ben Anderson Barrage NOL of 2.2 m AHD (see Section 2.1.4 of this report).

Table 12: Summary of the BWSS releases associated with fish transfer devices – Ben Anderson Barrage – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Ben Anderson Barrage fishway operation	7(e)	SL	26 35	L L	+/-- The fishway operates passively; however, operation is subject to storage level which, in turn, is dictated by conditions in upstream impoundments. The fishway operated 64% of the time in implementing the ROP.	The ecological effectiveness is intimately tied to other ROP rules (i.e. NOL) for the Ben Anderson Barrage. Low storage levels decrease opportunities for fish passage during important periods - reducing the effectiveness of the fishway.	Remove current rule. Increase the Ben Anderson Barrage NOL to 2.2 m AHD (above the fishway inlet level) to facilitate fishway operations.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.12 Releases associated with fish transfer devices–Kolan Barrage (ROP Attachment 4.1E Section 2.8.3)

"The Kolan Barrage fishway must be operated when the barrage storage is greater than 2m AHD. The releases must vary between 10ML/d when at 2m AHD and increase gradually to 19ML/d as water level rises to 2.7m AHD. The fishway must be fully open when the storage level is above 2.7m AHD. The fishway may be operated at other times, such as when meeting the system operational requirements."

This rule relates to EO 7(e) and strategies 26 and 35 of the WRP.

2.12.1 Implementation

Implementation of this rule is fairly straightforward as the fishway operates passively; however, fishway operation is subject to storage level which, in turn, is dictated by conditions in upstream impoundments. Nonetheless, the Kolan Barrage fishway operated nearly 100% of the time under the ROP (Figure 12) (see Implementation Review Report Appendix A Section 5.9).

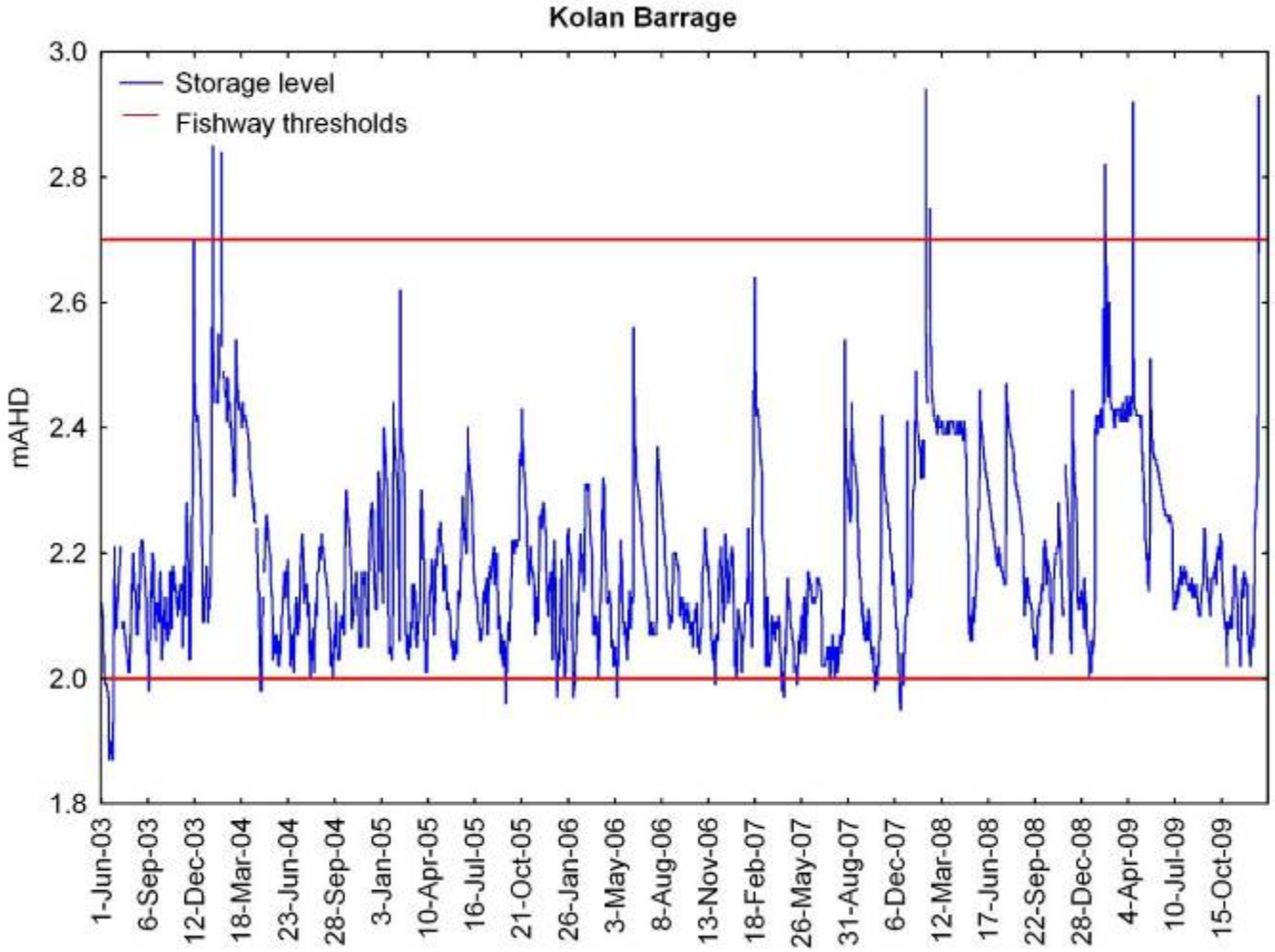

Figure 12: Kolan Barrage level for 2003 to 2009 associated with fishway operation.

2.12.2 Summary of monitoring and assessment

Monitoring for this rule was achieved through Sunwater reporting data.

2.12.3 Ecological effectiveness

The ecological effectiveness of this rule is intimately tied to other ROP rules (i.e. NOL) for the Kolan Barrage. The fishway operated consistently when water levels were within the range of the rule. It has been found that 22 species of fish utilise this fishway, numerically dominated by blue catfish (*Arius graeffei)* and boney herring (*Nematolosa erebi*) (Broadfoot et al. 2000).

2.12.4 Recommendations

The fishway operation rule should be removed as the operation is controlled by DAFF, with DNRM supporting the operation of the fishway by maintaining the Kolan Barrage NOL above the lower inlet of the fishway (see Section 2.1.4 of this report).

Table 13: Summary of the BWSS releases associated with fish transfer devices – Kolan Barrage – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Kolan Barrage fishway operation	7(e)	SL	26 35	L L	++ The Kolan Barrage fishway operated nearly 100% of the time under the ROP.	NOL in the Kolan Barrage ensures that the fishway operates for a high percentage of the time. It has been found that 22 species of fish utilise this fishway, numerically dominated by blue catfish (*Arius graeffei*) and boney herring (*Nematolosa erebi*)	Remove current rule. Maintain current Kolan Barrage NOL at 2m AHD to facilitate fishway operations.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.13 Releases associated with fish transfer devices–Paradise Dam (ROP Attachment 4.1E Section 2.8.4)

"The Paradise Dam fishway must be operated when the dam storage level is between 62m AHD and 67.9m AHD; and releases or overflows of greater than 14ML/d are being made from the dam. The fishway may be operated at other times when meeting system operational requirements."

This rule specifically relates to the operation of the downstream fishway. In contrast the upstream fishway can operate from a minimum storage level of 45m AHD. The fishway rule is related to EO 7(e) and strategies 26 and 35 of the WRP.

2.13.1 Implementation

Information on the implementation of this rule is limited, though SunWater reporting data indicates the downstream fishway could have been theoretically operational for 20%, and the upstream fishway 65%, of the time since construction (see Implementation Review Report Appendix A Section 5.9). Operation of both fishways has been restricted by the length of time taken for the dam to first fill, with this mainly affecting the operation of the downstream fishway (Figure 13).

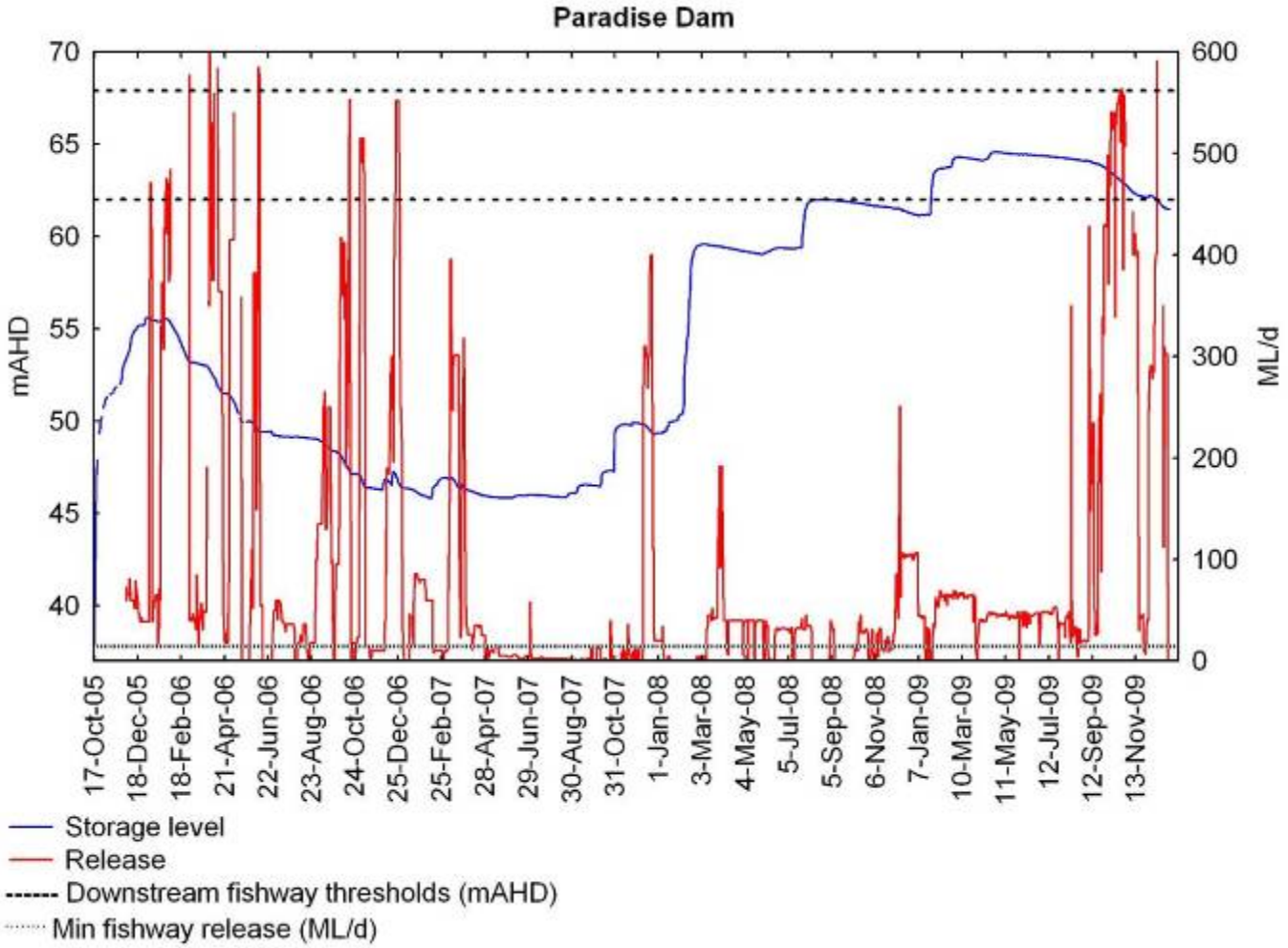

Figure 13: Paradise Dam level and releases for 2005 to 2009 associated with fishway operation.

2.13.2 Summary of monitoring and assessment

Monitoring for this rule includes SunWater reporting data and assessment of the fishway by DAFF – though this information is currently unavailable to DNRM.

2.13.3 Ecological effectiveness

The ecological effectiveness of this rule is undetermined due to unavailability of information.

2.13.4 Recommendations

The fishway operation rule should be removed as the operation is controlled by DNRM. Discussions are being held between DNRM, DAFF and SunWater to progress a fishway management plan for this structure.

Table 14: Summary of the BWSS releases associated with fish transfer devises – Paradise Dam – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Paradise Dam fishway operation	7(e)	SL	26 35	L	+/-- Operation of the upstream fishway was implemented for a small portion of time (~20% of time) The downstream fishway operation was limited due to the time taken for the dam to fill for the first time.	The ecological effectiveness of this rule is undetermined due to unavailability of information.	Remove current rule. Discussions are being held between DERM, DEEDI and SunWater to progress a fishway management plan for this structure.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

2.14 Quality of water downstream of storages (ROP Attachment 4.1E Section 3)

"Where infrastructure incorporates multilevel inlets, the ROL holder must draw water from the inlets that maximise the quality of the water released."

This rule relates to EO 7(b) and strategy 26 of the WRP. The intent of this rule is to ensure infrastructure releases are of a similar water quality to that upstream.

2.14.1 Implementation

Infrastructure with multi-level inlets in the BWSS includes Bucca Weir, Ned Churchward Weir and Paradise Dam. No significant deviations have been reported by SunWater (Annual Reports 2006 to 2010) in relation to the quality of water released, compared to that within these storages.

2.14.2 Summary of monitoring and assessment

SunWater reporting data contributes the bulk of monitoring for this rule; however, DNRM's EFAP monitoring has also collected relevant data. DNRM's stream flow gauging station network has also been utilised.

2.14.3 Ecological effectiveness

The ecological effectiveness of this rule is particularly important in locations where there is limited natural riverine habitat directly downstream of infrastructure. Although no significant water quality issues have been reported, comparison of the impoundment and tailwater water quality is difficult as both samples are not usually taken on the same day. Data collected as part of DERM's lungfish monitoring programme highlights considerable water temperature changes within, and below, Ned Churchward Weir within the critical spawning and recruitment period of August to December (see Implementation Review Report Appendix A Section 4.2.4). These temperature changes have the potential to delay spawning in some species, for example the minimum temperature found for lungfish spawning was 14.5^{o}C for Brooks & Kind (2002) and more recently 18^{o}C (Espinoza et al. unpub.). The latter temperature level is generally found in early spring and may be influenced by releases from Ned Churchward Weir. This issue highlights limitations in the operational procedures for Ned Churchward Weir releases.

2.14.4 Recommendations

Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and release data. Individual storage operating procedures may assist in maintaining or improving the delivery of the best quality water to downstream environments.

Table 15: Summary of the BWSS quality of water downstream of storages Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximise the quality of water released	7(b) Intent is to ensure infrastructure releases are of a similar water quality to that upstream.	SL	26	SL	+ Multi-level offtakes used to release best water quality.	Limited clear, pair-wise analysis that directly investigates simultaneous water quality within storages, and at their outflows Limitations in the operational procedures for Ned Churchward Weir releases cause cold water pollution downstream during the spring and early summer months. This could cause a delay in spawning of some species due to lack of temperature trigger or cue.	Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data. Data should be collected on the same day for each storage.

1 SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule

*2 ++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

3 Upper Burnett Water Supply Scheme

The Upper Burnett Water Supply Scheme (UBWSS) includes a number of instream water storages – Wuruma Dam, Kirar, Jones and Claude Wharton Weirs – and covers the Upper Burnett River to the top of the BWSS extent (see ROP Chapter 9 Map B). Several environmental management rules operate in the UBWSS based primarily on infrastructure releases and maintenance of particular storage water levels. The UBWSS was originally included in the ROP in 2003 with an amendment in 2005 to add in the operation of the newly constructed Kirar Weir.

The following sections reflect the order that the UBWSS environmental management rules are stated in ROP Attachment 4.2E.

3.1 Nominal Operating Levels of Storages (ROP Attachment 4.2E Section 1.1)

"The water level in a given storage must be maintained above that storage's nominal operating level by releasing water from the upstream storage in accordance with rules for releases between subschemes. The operator is permitted to draw down below these levels for up to seven days per month for operational reasons to allow for upstream releases to reach the storage or in unseasonal conditions."

Table 16 lists the nominal operating levels (NOL) for the UBWSS.

Table 16: NOL (m AHD) for Kirar and Claude Wharton Weirs

Storage	Operating Level (ML)	Operating Level (m AHD)
Kirar Weir	6 000	151
Claude Wharton Weir	4 100	91.12

This rule relates to EO 6(e)(iii) and 7(e) and strategy 26 of the WRP as the rule is associated with providing opportunity for the fishways on Claude Wharton and Kirar weirs to operate. However, the NOLs were primarily set to the depth at which the irrigator pumps within the pond would operate as well as providing a level that allowed inflows to rapidly fill and overtop the infrastructure.

3.1.1 Implementation

The Claude Wharton Weir NOL was maintained for ~84% of time from 2000 to 2009. In most years the NOL was able to be maintained for more than eleven months each year, however due to drought conditions in the 2006/07 and 2007/08 water years the NOL was not maintained for more than 250 and 120 days respectively.

The Kirar Weir NOL was maintained for ~21% of time from 2005 to 2009. This low percentage was a result of low levels in Wuruma Dam, which was unable to make releases to maintain the Kirar Weir NOL.

3.1.2 Summary of monitoring or assessment

Monitoring of the operation of the fishway on Claude Wharton Weir since construction in 2008 has revealed that it has been successful in allowing migration of a number of fish species. Furthermore, monitoring has shown that even modest flows of the magnitude of ~250ML/d were sufficient to illicit a migration response in a number of fish species including Australian lungfish, Australian bass and Golden perch which aggregate at the fishway entrance (Craig Broadfoot, pers comm. 2011).

There has been no monitoring of the fishway operation on Kirar Weir as there have been ongoing issues with the fishway operation since construction in 2005. DAFF have not been able to complete any monitoring and the fishway has not been in operation. The water level in Kirar Weir up until the end of the 2009 water year has been kept above the fishway entrance (150.4 m AHD) for more than 34% of time.

3.1.3 Ecological effectiveness

It has been shown that the fishway at Claude Wharton is capable of providing passage for a variety of fish species and the NOL provides water for the fishway to operate the majority of the time.

Due to the lack of monitoring data available for Kirar Weir, the ecological effectiveness of this rule cannot be assessed. As the NOL is set above the fishway entrance level, then the intent of the rule is to provide the opportunity for the fishway to operate when it is commissioned.

3.1.4 Recommendations

It is recommended that any review of the Kirar Weir and Claude Wharton Weir NOLs considers the height of the fishway entrances.

Table 17: Summary of UBWSS NOL of Storages Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Storage NOL	6(e)(iii) 7(e) NOL can be linked to fish movement, habitats.	ML SL	26	L	+ NOL was maintained in the vast majority of months for Claude Wharton Weir. NOL for Kirar Weir was only maintained for ~21% of time.	Kirar Weir fishway not monitored. Claude Wharton Weir NOL was above the fishway entrance on Claude Wharton Weir for the majority of time.	It is recommended that any review of the Kirar Weir and Claude Wharton Weir NOLs considers the height of the fishway entrances.

*1 SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule 2 ++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

3.2 Rate of release (ROP Attachment 4.2E Section 2.3)

"The ROL holder must minimise the occurrence of adverse environmental impacts (e.g. fish stranding and bank slumping) by ensuring that any change in the rate of release of water from storages occurs incrementally."

This rule relates to EO 7(c), 7(e) and 11(2) and strategy 26 of the WRP. The intent of this rule is to ensure that storage releases are controlled to minimise the risk of adverse environmental impacts (i.e. bank slumping, fish stranding and excessive scouring).

3.2.1 Implementation

An earlier version of the ROP required SunWater to apply to the chief executive for the approval of the maximum rate of release through the outlet works within 12 months of the commencement of the ROP. SunWater subsequently submitted these release rates, which are based on the ability to turn on and off releases within one day.

3.2.2 Summary of monitoring or assessment

An assessment of the gauged streamflow downstream of infrastructure confirmed that releases produce more frequent flow events than are found in unregulated reaches and that these releases are shut off over a shorter period of time (Figure 2). UBWSS infrastructure releases (measured at Jones Weir tailwater and Gayndah gauging stations) were shut down typically over a period 3 to 6 days, whereas the recession of natural flows was on average much longer at 10 to 19 days (Auburn River and Baffle Creek).

Data from the Eidsvold gauging station was analysed as it contains a mix of data from before and after construction of Kirar Weir. This site had an average rate of fall of ~10 days, which is similar to that of the natural sites. This is because the storage, completed in 2005, has only been above the NOL for 21% of the time; hence, flows at Eidsvold gauging station are mainly due to natural flow events. The persistence of flow events is important for water quality, food availability (macroinvertebrates) and inundation of habitat.

3.2.3 Ecological effectiveness

There were no significant bank slumping or fish stranding events in SunWater Annual Reports between 2004 and 2010 suggesting that the rate of release procedures were not causing adverse impacts to aquatic ecosystems.

3.2.4 Recommendations

It is recommended that the rate at which water is released for consumptive purposes better reflects natural flows. That is, instead of a constant release with a rapid rate of rise and fall at the start and end of the release, the release should incrementally reduce over a number of days to more closely mimic natural events. Rapid changes in rate of release can negatively impact the ecosystem through, for example, fish kills and desiccation of lungfish eggs – though no instances of fish kills have been identified through the reporting. As the ROP still allows the ROL holder to change the rate of release down from maximum outlet capacity to fully closed within one day, there is still a risk to other aspects of the aquatic ecosystem such as desiccation

of lungfish eggs during spring. It is recommended that the department work with SunWater to establish better practices relating to changing the rate of infrastructure releases.

Table 18: Summary of UBWSS Rate of Release Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximum rate of release	7(c) 7(e) 11(2) Controlling the rate of release assists in minimising the risk of adverse environmental impacts (i.e. fish stranding, bank slumping and excessive scouring).	L SL SL	26	L	++	No significant bank slumping or fish stranding events were reported. Potential impacts of infrastructure releases on the duration of flow events important for ecological processes such as lungfish recruitment. Persistence of flow events is important for water quality, food availability (macro-invertebrates) and inundation of habitat.	Refinement of this rule is required to mitigate these risks. This can be met by a stage reduction in rate of fall of releases.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

3.3 Low Flow Objectives–Claude Wharton Weir releases (ROP Attachment 4.2E Section 2.6.1)

"For Claude Wharton Weir the minimum releases shown in Table 19 are to be made during the specified months if the water level is greater than 91.12m AHD. These releases are subject to outlet restrictions and may be used to meet the requirements of entitlement holders."

Table 19: Claude Wharton Weir minimum release

Month	Inflow to Claude Wharton Weir (ML/d)	Releases from Claude Wharton Weir (ML/d)
June	Greater than 74	74
November	Greater than 109	109
December	Greater than 305	305

This rule relates to EO 7(a), 7(b), 7(c), 7(e) and 11(2) and strategies 25 and 26 of the WRP. The intent of this rule is to meet the WRP EFOs, in particular the 50% daily flow for each month.

3.3.1 Implementation

The low flow strategy was implemented successfully throughout the ROP period (2003 to 2009) (see Implementation Review Report Appendix A Section 5.2). Low flow releases were made in accordance with ROP requirements except when Critical Water Supply Arrangements (CWSA) were in effect (see Figure 14):

- 1st July to 19th December 2003
- 1st July to 17th November 2004
- 1st July 2006 to 2nd March 2007
- 1st July 2007 to 11th February 2008
- 1st July to 4th August 2008

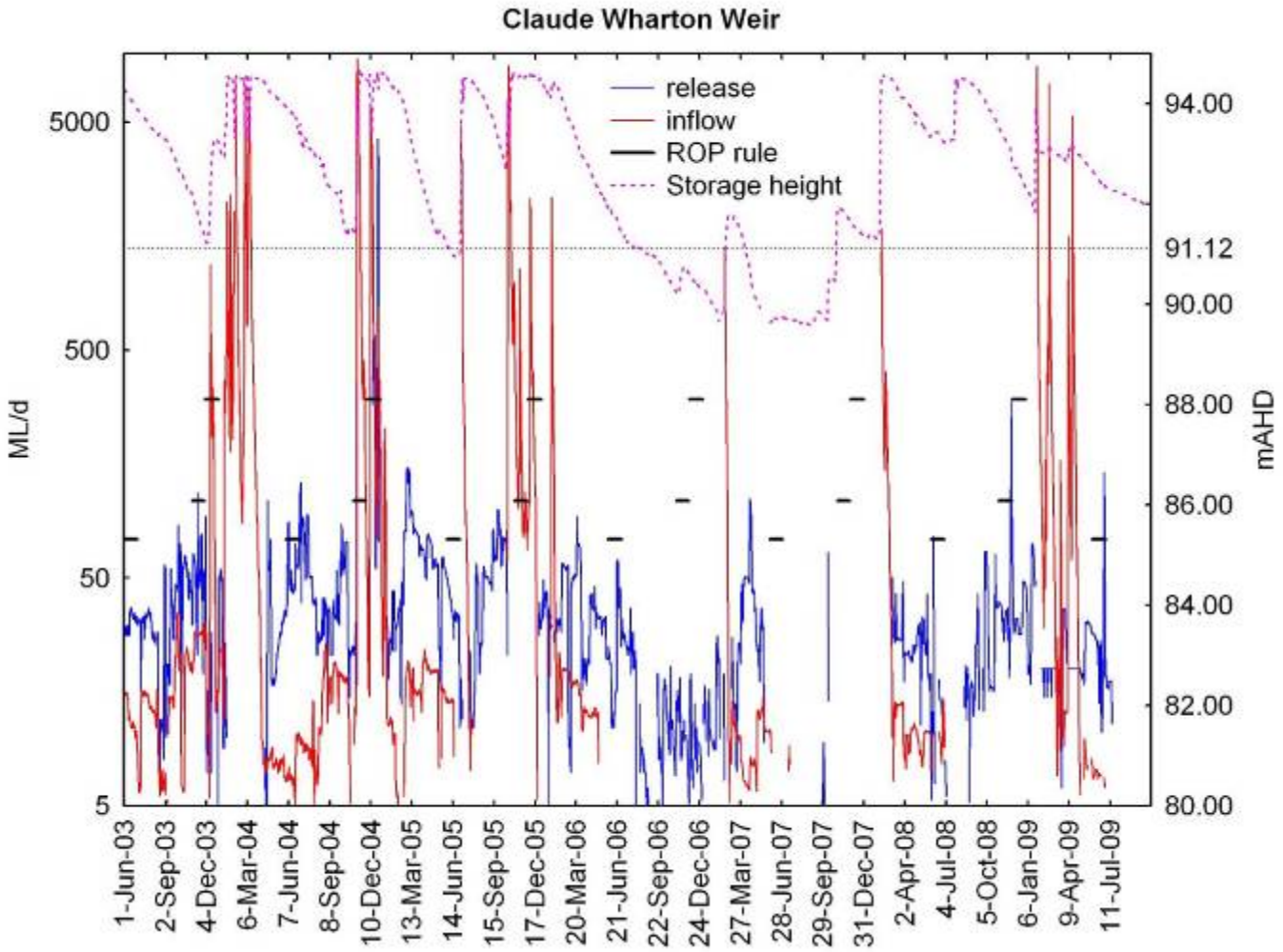

Figure 14: Claude Wharton Weir inflows, releases, storage height and ROP low flow release rule.

3.3.2 Summary of monitoring and assessment

Monitoring for this rule is mostly provided through SunWater reporting data, however some guidance has been provided by DEEDI officers regarding the size of releases used by fish as a stimulus to migrate.

3.3.3 Ecological effectiveness

The intent of the minimum passflow rule for June, November and December is to meet the 50th percentile daily flow objective in the WRP. These flows would serve to recharge downstream waterholes and maintain water quality within. These flows are also of a magnitude that may facilitate lungfish spawning and recruitment as well as providing stimulus for fish passage through the Claude Wharton Weir fishway (see Implementation Review Report Appendix A Section 4.2.4). As these releases are made for only three months of the year, the effectiveness of this flow strategy is limited only to those months. Aquatic biota use flows of these volumes to migrate as well as breed. Limiting releases to June and then not making further environmental releases until November (if triggered) limits the ability of the aquatic biota to complete these and other lifecycle processes. Cues for spawning for many species includes changes in water temperature and increasing day length. Limiting the months in which variable flow releases are made limits the opportunities as the external cues might be available, however the flow triggers are not present as they are captured by upstream storages.

3.3.4 Recommendations

It is recommended that this release rule is replaced with a targeted rule that provides a more natural flow regime such as an inflow/outflow arrangement which may be seasonal and is extended to other months than currently provided with different thresholds/pass flow volumes. These flow thresholds are suggested to be of the magnitude of ~250 ML/d as these volumes support lungfish spawning, provide cues for fish passage downstream of this site, as well as being of a magnitude that cues fish migration through the Claude Wharton Weir fishway (Craig Broadfoot, pers comm., 2011).

Table 20: Summary of UBWSS low flow objectives – Claude Wharton Weir minimum releases – Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Claude Wharton Weir 74ML/d (June), 109ML/d (November) and 305ML/d (December) releases	7(a) 7(b) 7(c) 7(e) 11(2) Rule not specifically linked to EO but is required to meet EFO.	L WL WL WL WL	25 26	L L	+ Rule has not been implemented on some occasions due to activation of CWSA.	Ecological intent unclear, however, flows would serve to recharge downstream waterholes, maintain water quality within, and are potentially of a magnitude that may facilitate lungfish spawning and recruitment.	Replace with a targeted rule that provides for a more natural flow regime such as an inflow/outflow arrangement that extends to other months of the year and changing the pass flow volumes.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

3.4 Quality of water downstream of storages (ROP Attachment 4.2E Section 3)

"Where infrastructure incorporates multilevel inlets, the ROL holder must draw water from the inlets that maximise the quality of the water that is released."

This rule relates to EO 7(b) and strategy 26 of the WRP. The intent of this rule is to ensure infrastructure releases are of a similar water quality to that upstream.

3.4.1 Implementation

Infrastructure with multi-level inlets in the UBWSS includes Wuruma Dam, Kirar Weir and Claude Wharton Weir. No significant deviations have been reported by SunWater (Annual Reports 2006 to 2010) in relation to the quality of water released, compared to that within, these storages.

3.4.2 Summary of monitoring and assessment

SunWater reporting data contributes the bulk of monitoring for this rule; however EFAP monitoring and gauging station ambient water quality is also used in this assessment.

No significant water quality issues have been reported through SunWater reporting. EFAP and ambient water quality monitoring has shown that there are seasonal increases in the electrical conductivity (EC) of the water downstream of Jones Weir (Implementation Review Report Appendix A Figure 3). These high readings of electrical conductivity (or salinity) of ~4 000 µS/cm have been observed when water levels are very low and there has been a significant period since a release from Jones Weir. Observation of the macroinvertebrate (aquatic insect) data showed that there was no significant deviation from expected data (Implementation Review Report Appendix A Table 2) and that the overall salinity data was within the acceptable bounds of the Queensland Water Quality Standards (Implementation Review Report Appendix A Table 2).

3.4.3 Ecological effectiveness

Although no significant water quality issues have been reported, comparison of the impoundment and tailwater water quality is difficult as both samples are not usually taken on the same day.

3.4.4 Recommendations

Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data.

Table 21: Summary of the UBWSS quality of water downstream of storages Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximise the quality of water released	7(b) Intent is to ensure infrastructure releases are of a similar water quality to that upstream.	SL	26	SL	++ Multi-level offtakes used to release best water quality.	No significant water quality issues have been reported on.	Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data. Data should be collected on the same day for each storage.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

4 Barker Barambah Water Supply Scheme

The Barker Barambah Supply Scheme (BBWSS) includes several instream water storages – Bjelke-Peterson Dam, Joe Sippel and Silverleaf Weirs – and covers the Barker and Barambah Creeks (see ROP Chapter 9 Map B). Although the ROP states rules for infrastructure releases (compensation flows) and maintenance of particular storage water levels, these are not considered here as environmental management rules. The BBWSS was originally included in the ROP in 2005 with an amendment in 2010 to include revised CWSA.

The following sections reflect the order that the BBWSS environmental management rules are stated in ROP Attachment 4.3E.

4.1 Rate of release (ROP Attachment 4.3E Section 2.3)

"The ROL holder must minimise the occurrence of adverse environmental impacts (e.g. fish stranding and bank slumping) by ensuring that any change in the rate of release of water from storages occurs incrementally."

This rule relates to EO 7(c), 7(e) and 9 and strategy 26 of the WRP. The intent of this rule is to ensure that storage releases are controlled to minimise the risk of adverse environmental impacts (i.e. bank slumping, fish stranding and excessive scouring).

4.1.1 Implementation

An earlier version of the ROP required SunWater to apply to the chief executive for the approval of the maximum rate of release through the outlet works within 12 months of the commencement of the ROP. SunWater subsequently submitted these release rates, which are based on the ability to turn on and off releases within one day.

4.1.2 Summary of monitoring and assessment

No bank slumping or bank erosion incidents were reported in SunWater's Annual Reports, from 2006 to 2010, immediately downstream of BBWSS storages. Similarly, no fish stranding incidents were reported.

SunWater reporting data contributes the bulk of monitoring for this rule, however, updated ecological information particularly relating to lungfish spawning and recruitment may also be relevant. An assessment of the gauged streamflow downstream of infrastructure elsewhere in the Burnett Basin confirmed that releases produce more frequent flow events than are found in unregulated reaches and that these releases are shut off over a shorter period of time (Figure 2). BBWSS infrastructure releases (measured at Ban Ban gauging station) were found to more closely replicate the recession of natural flows (average rate of fall of ~10 days). The outlet on Bjelke-Petersen Dam is relatively small (400 ML/d) and releases at maximum discharge fairly infrequently. In addition, the departmental gauging station (~130 km downstream) documents that any impacts from changes in release rates are mitigated.

4.1.3 Ecological effectiveness

There were no significant bank slumping or fish stranding events in SunWater Annual Reports between 2006 and 2010 suggesting that the rate of release procedures were not causing impacts on the aquatic ecosystems located downstream of the Barambah Creek gorge.

4.1.4 Recommendations

It is recommended that the rate at which water is released for consumptive purposes reflects natural flows as much as possible. No significant changes are required to rates of release for this scheme.

Table 22: Summary of BBWSS Rate of Release Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximum rate of release	7(c) 7(e) 9	L SL L	26	L	+ No reports of bank slumping/erosion or fish stranding incidents.	No significant bank slumping or fish stranding events were reported.	Refinement of this rule is not required in the scheme.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

4.2 Quality of water downstream of storages (ROP Attachment 4.3E Section 3)

"Where infrastructure incorporates multilevel inlets, the ROL holder must draw water from the inlets that maximise the quality of the water that is released."

This rule relates to EO 7(b) and 9 and strategy 26 of the WRP. The intent of this rule is to ensure infrastructure releases are of a similar water quality to that upstream.

4.2.1 Implementation

Infrastructure with multi-level inlets in the BBWSS includes Bjelke-Peterson Dam, Joe Sippel Weir and Silverleaf Weir. No significant deviations have been reported by SunWater (Annual Reports 2001 to 2009) in relation to the quality of water released, compared to that within these storages.

4.2.2 Summary of monitoring and assessment

SunWater reporting data contributes the bulk of monitoring for this rule. There were no issues that arose from analysis of release water quality data downstream of Bjelke-Peterson Dam (Implementation Review Report Appendix A).

4.2.3 Ecological effectiveness

Although no significant water quality issues have been reported, comparison of the impoundment and tailwater water quality is difficult as both samples are not usually taken on the same day.

4.2.4 Recommendations

Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data.

Table 23: Summary of the BBWSS quality of water downstream of storages Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximise the quality of water released	7(b) 9 Intent is to ensure infrastructure releases are of a similar water quality to that upstream.	SL ML	26	SL	* Multi-level offtakes used to release best water quality.	Limited clear, pair-wise analysis that directly investigates simultaneous water quality within storages, and at their outflows. No significant water quality issues have been reported on.	Maintain rule. Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data. Data should be collected on the same day for each storage.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

5 Boyne River and Tarong Water Supply Scheme

The Boyne River and Tarong Water Supply Scheme (BTWSS) includes one large instream water storage – Boondooma Dam – and covers the Boyne River to the confluence with the UBWSS (see ROP Chapter 9 Map B). Some environmental management rules operate in the BTWSS based primarily on infrastructure releases and maintenance of particular storage water levels. The BTWSS was included in the ROP in 2007 (Attachment 4.4E).

5.1 Quality of water downstream of storages (ROP Attachment 4.4E Section 3)

"Where infrastructure incorporates multilevel inlets, the ROL holder must draw water from the inlets that maximise the quality of the water that is released."

This rule relates to EO 7(b) and 10(a) and strategy 26 of the WRP. The intent of this rule is to ensure infrastructure releases are of a similar water quality to that upstream.

5.1.1 Implementation

Boondooma Dam is the major storage on the BTWSS, and it contains multi-level inlets. No significant deviations have been reported by SunWater (Annual Reports 2007 to 2010) in relation to the quality of water released, compared to that within the storage.

5.1.2 Summary of monitoring and assessment

SunWater reporting data contributes the bulk of monitoring for this rule. There were no issues that arose from analysis of release water quality data from downstream of Boondooma Dam (Implementation Review Report Appendix A).

5.1.3 Ecological effectiveness

Although no significant water quality issues have been reported, comparison of the impoundment and tailwater water quality is difficult as both samples are not usually taken on the same day.

5.1.4 Recommendations

Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data.

Table 24: Summary of the BTWSS quality of water downstream of storages Assessment

Rule	Ecological Outcome	Link[1]	WRP Strategy	Link[1]	Implementation success[2]	Ecological Effectiveness	Recommendations and comments
Maximise the quality of water released	7(b) 10(a) Intent is to ensure infrastructure releases are of a similar water quality to that upstream.	SL ML	26	SL	* Multi-level offtakes used to release best water quality.	Limited clear, pair-wise analysis that directly investigates simultaneous water quality within storages, and at their outflows. No significant water quality issues have been reported on.	Maintain rule. Reporting requirements for this rule should be made more explicit in order to facilitate the transparency of potential water quality issues associated with infrastructure releases, especially in terms of paired inflow, storage and outflow data. Data should be collected on the same day for each individual storage.

[1] *SL Strong link to rule, L Link to rule, ML Mostly link to rule, WL Weak link to rule*

[2] *++ Implemented, + Usually/occasionally implemented, -- Infrequently implemented, ---- Never implemented, * Not discernable*

6 Three Moon Creek Water Supply Scheme

The Three Moon Creek Water Supply Scheme (TMCWSS) includes several instream water storages – Cania Dam and Youlambie, Monto, Bazley, Avis and Mulgildie Weirs. The TMCWSS has yet to be included in the ROP and currently operates under an interim resource operations licence (iROL) issued to SunWater in June 2008.

6.1 Cania Dam Environmental Provisions (iROL Schedule 1.1)

"During periods of low water levels in Three Moon Creek from AMTD (Adopted Middle Thread Distance) 110.1 lm to AMTD 105 km, releases may be made to support a community of platypus from AMTD 110.1 km to AMTD 105 km taking into account advice from the Environmental Protection Agency (EPA) regarding releases for this purpose."

This rule is related to EO 6(e), 7(a) and 7(b), and strategies 26 and 27 of the WRP. The intent of this rule is primarily to provide persistence of waterholes immediately downstream of Cania Dam that have contained platypus in the past.

6.1.1 Implementation

The implementation of this rule is difficult to monitor and assess as this rule only applies where a release has been requested by the former EPA. Recent discussions with the ranger at Cania Gorge National Park has revealed that SunWater communicates with the rangers when releases are to be made for groundwater recharge, however the ranger suggested they were not aware releases could be requested (Peter Pickering, pers comm. 2010). In addition, SunWater planned to wet this 5 km reach prior to specific large groundwater recharge releases, however this may have not been done (correspondence to the department dated 17/9/2005).

6.1.2 Summary of monitoring and assessment

SunWater online release information contributes the bulk of monitoring for this rule. The release information suggests three irrigation releases have been made since 2005 (started 31/7/2006, 2/6/2008 and 31/5/2010) with releases going from 0 ML/d to 125 ML/d and 325 ML/d within the first day of release. There has not been any smaller releases to "wet the 5 km reach" prior to any of these releases.

6.1.3 Ecological effectiveness

The ecological intent of this rule is sound as it provides for the persistence of these waterholes however the releases are based on requests and not actual inflow information. To date no releases have been made for this purpose resulting in the waterholes immediately downstream of the dam drying out over the past few seasons (Peter Pickering, pers comm. 2010). These are not permanent waterholes as these are very restricted pools, with local anecdotal evidence suggesting that platypus move downstream to permanent waterholes when the smaller waterholes begin to dry out.

6.1.4 Recommendations

If the intention is to provide permanent water in the waterholes immediately downstream of the dam, then replace the rule with a targeted rule that provides a more natural flow regime such as an inflow/outflow arrangement for the persistence of these waterholes immediately downstream of Cania Dam. This rule should be included in the ROP amendment to include the Three Moon Creek Water Supply Scheme. However, if the intention is to provide provision of flows to the permanent waterholes further down the creek, the existing provisions are sufficient.

7 Elliott, Isis and Gregory Rivers

The Elliott, Isis and Gregory rivers include only minor instream water storages and have yet to be included in the ROP. As such, there are no environmental management rules in place in these areas; however licence conditions provide some level of protection to river flows. Assessment of these current arrangements provides guidance on whether specific strategies are required in the new WRP.

7.1 Licence conditions for the Elliott River catchment

Licence conditions are used to manage take by water harvesters (flow threshold) and waterhole users (pump size). A Moratorium on the construction of overland flow storages was released on 18 January 2010.

These licence conditions are indirectly related to EO 12 and strategy 28 of the WRP. The intent of these conditions is to limit the take of water and to minimise impact on other users as well as the environment.

7.1.1 Implementation

These licence conditions have been in effect since the licences were created.

7.1.2 Summary of monitoring and assessment associated with this rule

Monitoring of the Elliott River catchment waterholes and estuary has been conducted as part of EFAP. The risk assessment suggests that there is an existing risk to the estuary from the capture of smaller flow events by water harvesting (and subsequent to the modelling, overland flow storages) (see Implementation Review Report Appendix B). In addition, there has been a slightly higher risk to waterholes through more frequent drawdown, however this drawdown effect is minimised as the waterholes are quite deep and persistent. This persistence is due to the high level of connectivity with the groundwater (see Implementation Review Report Appendix A).

7.1.3 Ecological effectiveness

Although the riverine habitats and river forming processes have remained relatively unaffected, smaller flow events have been impacted through the capture of water by overland flow dams, water harvesting and reduced waterhole levels. These events provide the more frequent flushing of the estuary and provide the connectivity between freshwater and estuarine environments.

7.1.4 Recommendations

Limit any further development in this catchment to minimise further risks. See full risk assessment in Appendix B of the Environmental Assessment Report.

7.2 Licence conditions for the Isis and Gregory River catchments

Licence conditions are used to manage take by water harvesters (flow threshold) and waterhole users (pump size). A moratorium on the construction of overland flow storages was released on 18 January 2010.

These licence conditions are indirectly related to EO 12 and strategy 28 of the WRP. The intent of these conditions is to limit the take of water and to reduce impact on other users as well as the environment.

7.2.1 Implementation

The licence conditions have been in effect since the licences were created.

7.2.2 Summary of monitoring and assessment associated with this rule

The risk assessment for the estuarine habitat indicated that neither estuary has been substantially affected by the current level of development (see Appendix B of the Environmental Assessment Report).

7.2.3 Ecological effectiveness

With other external factors aside, there has been minimal impact on the ecosystem through the management of the existing water resource.

7.2.4 Recommendations

As there is limited water resource development within these catchments, the level of impact to the ecosystem is minimal. To maintain these catchments in this state, it is recommended that further development in these catchments is minimised.

8 Conclusions

The ROP has been in place since 2003, with environmental management rules in force for a variable period through the inclusion of additional water supply schemes over time. This, together with the specific details of rules changing based on new information (for example Fred Haigh Dam releases), has made assessment and application of many rules difficult.

The most valuable rules within the ROP are those that are intimately linked to ecological outcomes and strategies within the WRP. Unfortunately, in most cases, these links are not well defined and difficult to discern. The Bucca Weir release rule is an example of a rule that has had a benefit to the environment, links to the WRP, but could be adjusted to achieve a better outcome for the environment and also water allocation holders.

Most of the environmental management rules in the ROP were found to be well implemented however, there were often problems with this implementation. The activation of environmental management rules have been, in some cases, overruled by critical water sharing arrangement–reducing the potential effectiveness of the rule. In other cases, on review, the application of a rule in a specific situation is questionable, for example, the Bucca Weir release rule which provides a comparatively small release after potentially very large extended wet season flows. This suggests that there is currently low adaptability in terms of management of the environmental management rules in the ROP.

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