Managing environmental flows in an agricultural landscape: the Lower Gwydir floodplain

Final Report to the Australian Government Department of the Environment, Water, Heritage and the Arts

September 2009

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Cotton Catchment Communities CRC

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Cover photos
Top: Copeton Dam (Photo: N. Foster); second: Gingham Watercourse at “Willowlee” (Photo: G. Wilson); third: Gingham Watercourse at “ Boyanga Waterhole” (Photo: G. Wilson); bottom: Gingham floodplain at “Crinolyn” (Photo: P. Berney).

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Inundated wetland on “Bunnor” in December 2007, Gingham Watercourse floodplain. Photo: P. Berney.

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Executive summary

The Lower Gwydir floodplain is recognised for its high-conservation value as aquatic plant and wildlife habitat. This, along with the significance of the terminal wetland areas for water bird breeding, has resulted in parts of the floodplain being included, in the late 1990s, on the List of Wetlands of International Importance under the Ramsar Convention on Wetlands. However, construction of Copeton Dam upstream in the mid 1970s and subsequent changes to the region's irrigation, grazing and cropping industries has altered flow patterns into the wetlands and placed other pressures on the wetlands and their biodiversity values. The Gwydir Regulated River Water Sharing Plan was developed in the early 2000s, in part to counter further wetland degradation and to establish an allocation balance between consumptive and environmental needs. A broad stakeholder committee (the Gwydir Environmental Contingency Allowance Operations Advisory Committee; ECAOAC), currently administered through the NSW Department of Environment, Climate Change and Water, is the primary mechanism by which the subsequent flow allowance is used for environmental benefit. It is the overarching aim of the present study to determine the ecological responses to flow variability in the Lower Gwydir aquatic ecosystem, and to provide the ECAOAC with a model to guide the effective management of flows to maximise ecological responses in this system. The listing of wetlands on "Old Dromana", "Crinolyn", "Goddard's Lease" and "Windella" with the Ramsar Convention will continue to be a major driver of delivering environmental flows into the Lower Gwydir floodplain.

Objective 1. To determine the flow requirements of streams and terminal wetlands on the Lower Gwydir floodplain

A review of the availability of existing aquatic ecological knowledge on the Lower Gwydir floodplain revealed relatively few data specific to this ecosystem. Most available information focused on water quality and chemical parameters, the fish and macroinvertebrate assemblages and the responses of floodplain wetland vegetation to inundation and grazing. The construction of Copeton Dam was identified as having had profound impacts on hydrological patterns in the Gwydir floodplain, with a significant reduction in flood frequency, duration and extent. Even though water quality parameters have improved considerably over the last decade, ANZECC guidelines are still frequently breached. Increases in water turbidity and nutrient levels are linked to flow events.

There is little knowledge on algal and in-stream vegetation along Lower Gwydir watercourses. The high turbidity probably restricts algal and macrophyte growth to shallow areas and suitable substrate. However, the Lower Gwydir floodplain wetlands are a highly significant wetland habitat for NSW and the northern Murray-Darling Basin. Their vegetation communities are closely linked to inundation patterns, with distinct plant communities being associated with the area's flood history. Nevertheless, the floodplain vegetation has changed profoundly since development of Copeton Dam, and additional grazing pressure also impacts the response of native wetland vegetation following inundation. Core wetland areal extent is thought to have declined by around 90%.

Micro- and macroinvertebrates are an important component of aquatic ecosystems, although most available knowledge of these assemblages for the Lower Gwydir is limited to a comparison with similar river systems in the Murray-Darling system and several egg-bank emergence experiments. Gwydir wetlands support up to 500 macroinvertebrate species and the microinvertebrate community is comparable to other temporal wetlands in the Murray-Darling basin. The Lower Gwydir watercourses also contain at least nine native fishes, some of which are rare or endangered and of strong angling interest, and three exotic species. Changes in flow regime are thought to have been detrimental to the region's native fishes but may have favoured the exotic species. Additionally, weirs and rock crossings are a common feature in the Lower Gwydir catchment and are thought to restrict the movement of native fish, particularly upstream. The Lower Gwydir wetlands are also home to a species-rich frog community and aquatic reptiles such as turtles and the Murray-Darling carpet snake.

Conceptual models are important tools for scientific ecological studies, assisting with the development of research questions and guiding the choice of ecosystem components that need to be monitored. We constructed two separate conceptual models for in-stream and floodplain responses to flow variability to help better predict the ecological responses to flow events in the study system and to assist in the choice of ecological response variables in the field component of the study.

Three ECA releases occurred during the project interval, in December 2006, April 2007 and November 2007, with the objective of wetting core wetland areas. All fieldwork from October 2006 to February 2009 was timed to allow sampling before and after these releases. In-stream ecosystem components were sampled on eleven occasions, from October 2006 to February 2009, in the Gingham Watercourse and Gwydir and Mehi rivers, while monitoring of the response of vegetation in nearby floodplain wetlands to ECA events was undertaken on seven occasions from March 2007 to April 2008. Other analyses of long-term vegetation responses to flows and herbivore grazing utilised data from a series of grazing exclosure sites, established in 1994. Some monitoring was also undertaken in a series of floodplain lagoons to the north of the Gingham Watercourse.

The responses of wetland vegetation to inundation were first examined alongside the effects of herbivore grazing using data collected from May 1994 to March 2008. Inundation was found to have the greater influence on the dynamics of the wetland plant communities, and grazing was found to affect plant communities in different ways depending on the dominant plant species and antecedent soil-moisture conditions. In marsh club-rush communities, grazing resulted in a break-down of the dense canopy formed by this tall species. As a consequence, more light reached the ground and a range of other native species such as swamp buttercup and knotweeds could grow. However, in water-couch communities, grazing helped to maintain the dominance of this species by removing taller herbaceous species that shade the water-couch.

The response of vegetation to flooding from individual ECA releases varied markedly depending on the season of release. The vigour of the response was far higher in summer, the time of the year when native perennial species are growing actively. Native species then successfully competed with the invasive weed lippia, leading to a reduction in lippia cover following the flow. Following an autumn release, the initial growth of key species such as water couch was halted with the onset of winter frosts. Seasonal conditions, combined with grazing of the previously flooded sites, meant that few benefits of the ECA release were evident at the beginning of the following spring.

We measured a range of water chemistry parameters in the Lower Gwydir waterways. Our samples showed that the overall water quality was poor in the three waterways, with high nutrient and sediment loads. Flow releases for both ECA and other purposes either reduced nutrient concentrations through a dilution effect or increased concentrations. Additionally, given the higher discharge levels during releases, actual nutrient and sediment loads increased during flow events even when apparent nutrient concentrations were diluted by higher discharge.

We found a total of twelve freshwater fishes in the Lower Gwydir watercourses, 3 of which were exotic species. The fish community was dominated by only a few species (bony bream, spangled perch and carp gudgeon), while most other species were only caught in low numbers. European carp was the most common exotic species, dominating the fish assemblage from a biomass perspective. There was a change in fish assemblages along an upstream-downstream gradient, with many of the less-common native species occurring predominantly in upstream sites on the three watercourses. This pattern was especially pronounced in the Gingham Watercourse.

The variable hydrograph and the timing of multiple flow events in each season made it difficult to distinguish flow responses from seasonal variability in fish communities. Recruitment was observed in spangled perch, bony bream, carp gudgeon, and carp, while smaller numbers of juvenile smelt, un-specked hardyhead, and goldfish were also observed. Juveniles of other taxa such as golden perch, eel-tailed catfish, and Murray cod were present only in low abundances. Pulsed flow events (including ECA releases) did not result in a consistent response of fish assemblages, and responses varied between rivers and seasons. The lack of a clear response of fishes to flow releases suggests that factors other than recent hydrology may be determining fish assemblages in Lower Gwydir waterways. The lack of a clear response of Lower Gwydir fish assemblages to the ECA flow events may reflect a less important role of minor flow events on fish recruitment in these river systems or may in part reflect the hydrological characteristics of recent ECA releases.

The benthic invertebrate community comprised over 70 taxa, with rotifers and microcrustacea being the most speciose groups. At the temporal scale of our sampling, flow variability appeared to only explain part of the variation in the invertebrate community composition of the Lower Gwydir River. Similar to fish, we could not detect a consistent response to flow releases in macrocrustacean (shrimp and yabby) abundances, and both temporal and spatial abundances did vary widely between the three study channels.

Management recommendations

- Delay grazing or maintain low stocking rates during the initial stage of wetland flooding to allow fragile plant species in the amphibious responder functional group to flower and set seed.
- Maintain conservative cattle stocking rates (0.3-0.5 animals per hectare) to protect key native species from over grazing.
- The spatial extent of impact of an ECA flow on wetland vegetation and the duration of flooding are likely to be maximised when ECA releases follow a natural flood event.
- Continue to include event-based vegetation monitoring in any reporting of ecological outcomes from Lower Gwydir ECA releases. Include the four sets of grazing-exclosure plots in this schedule. Future monitoring of vegetation responses to ECA flows should include quantifying changes in biomass as well as percent foliar cover.
- Include event-based in-stream monitoring in relation to reporting ecological outcomes from future Lower Gwydir ECA releases.

- Recognise that ecological responses to flow events will likely differ seasonally. Although significant flood events have occurred in winter in the Lower Gwydir floodplain, the region has a summer-dominant rainfall pattern and the timing of future ECA events should match this whenever possible.

Objective 2. To develop recommendations for future flow management, monitoring indicators, and institutional arrangements for the Lower Gwydir aquatic ecosystem

ECA releases throughout the study period were of a limited and relatively stable stage height, designed to deliver the volume anticipated necessary to inundate the core wetland and to minimise losses onto the floodplain upstream of the target area(s). This may have limited the in-channel responses of some water chemistry parameters and faunal assemblages. Expectations of what ecological responses might be achieved by future ECA releases into the Lower Gwydir floodplain will need to be realistic. It may be necessary to consider a multi-release program to satisfy as many ecological objectives as possible. 'Piggy-backing' ECA flows on transfers for stock and domestic or irrigation purposes might be an effective strategy for facilitating multiple releases of differing stage height. Where an ECA release is made to benefit core wetland areas, attempts should be made to maximise the duration of floodplain inundation. Again, the best means of achieving this in the Lower Gwydir appears to be through piggy-backing releases onto natural flow events.

The variable nature of dryland river ecology means that data sets longer than the present 3-year study will be essential if we are to fully appreciate the responses of the Lower Gwydir ecosystem to managed releases or flow variability more generally. Future monitoring should include measurement of responses to individual ECA events, but also provide data from a longer sequence of varying seasonal and discharge conditions. Such a program should be structured in an event-based way but also allow for monitoring of low-flow and winter periods away from the usual spring-summer interval of higher flows. It will be critical that any future monitoring program be able to account for likely differences in temporal scale of response among biotic or other variables, as not all responses will be adequately detected by a single monitoring sequence. It may be necessary to monitor different variables at varying temporal scales, from days to weeks or months following the onset of a flow event. It will also be necessary to include a careful array of reference/control sites away from the target of any future ECA flows.

It is recommended that monitoring of the present suite of water chemistry parameters be continued. As wetland vegetation seems likely to remain a key ecological objective for ECA releases, future Lower Gwydir monitoring should include these assemblages and the series of UNE grazing-exclusion plots. In addition, it is recommended that further investigations examine the impact of flooding frequency on soil condition and the response of floodplain soils to wetting and drying, and to establish monitoring protocols for soil chemistry and biology. While we also recommend monitoring of fish be continued in Lower Gwydir channels, it is vital that this facilitate a stronger understanding of the lifehistory of key fishes within the Lower Gwydir ecosystem and we suggest that monitoring include responses such as spawning activity. The effect of in-stream barriers on Lower Gwydir fish assemblages also needs to be established.

In order to maintain the current momentum of research on the Lower Gwydir aquatic ecology, and to meet the invariable longer-term requirements of any monitoring program, we recommended that formal collaborative partnership arrangements be established between

research organisations and management agencies. There also remains a clear need to establish a repository of long-term ecological data on the Lower Gwydir aquatic ecosystem.

Management recommendations

- Expectations of what ecological responses might be achieved by a particular release need to be realistic. Any one release is unlikely to satisfy the hydrological requirements of all aquatic biota or ecosystem components.
- It may be necessary to establish a more variable hydrograph for ECA releases, in order to satisfy as many ecological objectives as possible.
- 'Piggy-backing' ECA flows on bulk releases for stock and domestic or irrigation purposes may be an effective strategy for facilitating multiple releases of differing stage height. However, the delivery point(s) for these flows and the channel reaches where the ecological outcomes are desired would need to match. Moreover, it will be necessary to establish whether there is significant loss of ecological responses (e.g. larval fish) through abstraction of the associated consumptive flows.
- Recognise that ecological responses to flow events will likely differ seasonally. Although significant flood events have occurred in winter in the Lower Gwydir floodplain, the region has a summer-dominant rainfall pattern and the timing of future ECA events should match this whenever possible.
- ECA events should also maximise the duration of wetland inundation. The best means of achieving this in the Lower Gwydir appears to be through piggy-backing releases onto natural flow events.
- Continue to include event-based monitoring of both in-stream and floodplain wetland environments in relation to reporting ecological outcomes from Lower Gwydir ECA releases. Long-term data sets will be necessary to adequately determine the extent to which Lower Gwydir aquatic populations fluctuate in response to seasonal, hydrological and structural habitat factors. Prioritise the collection of data on water chemistry, fish populations, wetland vegetation and waterbird assemblages.
- Continue monitoring of the grazing exclosures, and promote their protection and benefits to relevant landholders.
- Ensure that future monitoring be undertaken at a temporal scale relevant to the monitored parameters, and that it includes independent control areas.
- Ensure close communication between the ECAOAC and any research or agency staff directly involved in future monitoring and research activities.
- Establish a central repository of long-term ecological data on the Lower Gwydir wetlands ecosystem.
- Ensure that data and other scientific information is made available in a timely manner to inform management plans and adaptive management processes. This may include, for example, incorporation into decision support tools such as ecosystem response models, modification of spatial and temporal monitoring and data collection techniques, or improved management practices to support species such as fish and waterbirds.
- Support future research on the response of wetland soils to inundation and their role in supporting wetland condition and function.
- Support future research on the population ecology of fish, particularly the effect of flow variability on early growth and body condition.
- Establish the effects of in-stream barriers on Lower Gwydir fish assemblages.
- Establish whether Lower Gwydir fish assemblages vary with structural habitat within and between channels.

Objective 3. To provide managers of the *Gwydir Regulated River ECA* and other river flows into floodplain terminal wetlands with a model guiding the effective management of flows to maximise environmental outcomes

During the study interval, ECA releases were made during spring-summer and late autumn, and we summarised anticipated responses of fish and wetland/floodplain vegetation to releases in these two broad periods. Spring-summer releases are expected to generally produce greater cover of amphibious plants and flowering and seed setting, although reduced cover of terrestrial species. Some amphibious species may partially outcompete weed species such as lippia. Releases during this time would be expected to produce a moderate to strong recruitment response in a range of fish species, although this may include European carp. By contrast, releases during autumn to early winter are expected to produced more limited increases in the cover of amphibious plants although without significant flowering or seed setting. Fish recruitment responses are also likely to be limited at this time of year. Terrestrial plant species are likely to benefit more from releases in autumn-winter than in spring-summer.

This information should be considered in the finalisation and implementation of the *Gwydir Wetlands Adaptive Environmental Management Plan* and *Gwydir Wetlands Decision Support System*.

Management recommendations

- Take seasonal differences in ecological response to flow events into account when planning annual ECA release schedules.
- Ensure that the Gwydir Environmental Management Plan and the Gwydir Wetlands Decision Support System software both incorporate the latest scientific findings on Lower Gwydir aquatic ecological responses to flow variability.