Water Quality in the Gwydir Valley Watercourses

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INTRODUCTION

Irrigators are frequently accused of causing a deterioration of water quality in the Murray Darling Basin. For many catchments, such as the Gwydir in Northwest NSW, little reliable information is available to assess the impact of irrigation on water quality.

The aim of this research is to measure the water quality (in terms of sediment, salts and nutrients) of the Gwydir Valley Watercourses. By monitoring water quality above, within and below the irrigation area, any changes in water quality within the irrigation area can be examined to determine the impact of irrigation. Water quality data was also combined with river flow data to determine the quantity (load) of sediments, salts and nutrients that may leave the Gwydir Valley and enter the Murray Darling Basin.

METHODS

Location

The Gwydir Valley River Catchment is located in North West NSW. The Gwydir Catchment covers an area of approximately 26500 km^2 and is a part of the Murray Darling Basin. Water from the Gwydir River supports a major irrigation industry, with 86,000 hectares licensed for irrigation. Water from Copeton Dam is delivered to irrigators whose farms are located along the Gwydir, Carole, Mehi and Moomin watercourses.

Sample collection and laboratory analysis

Twenty water sampling sites were selected within the Gwydir Valley as shown in Figure 1. Water samples were collected at Gravesend (site 1) to determine the quality of flow from Copeton Dam, and also within the irrigation area along the Carole, Gil Gil, Gwydir, Mehi and Moomin watercourses (sites 2 – 17) through to the junction with the Barwon River (sites 18 – 20). Individual sites were chosen based on location and representation of local area, ease of access during wet conditions along with the location of a gauging station for records of water heights and flow rates.

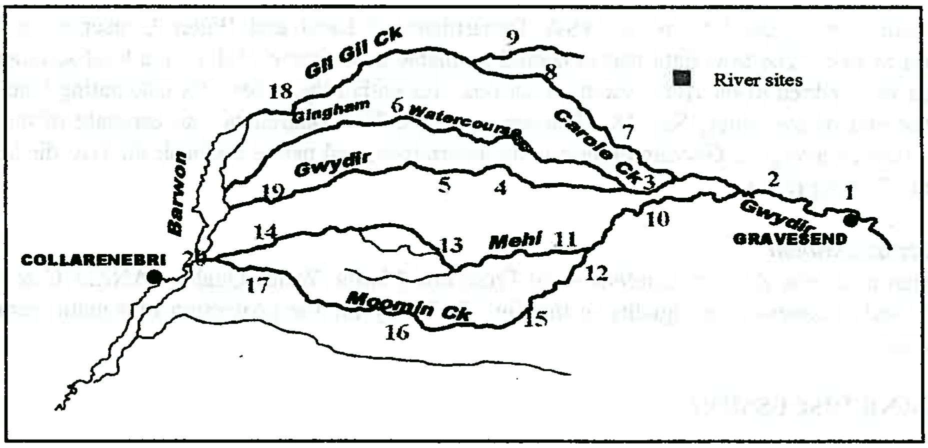

Fig. 1 Location of water sampling sites

Sampling commenced in October 1998 and continued until July 2001. Water samples were collected weekly over summer, fortnightly during March, April, October and November, and monthly during the remainder of the year.

Samples were taken from the middle of the river using a sampling pole, from the side of the river/creek or from off a bridge in order to sample from the area of most flow. Water samples were taken approximately 25 cm below the water surface or at mid-depth where the stream was too shallow using acid-washed, samplerinsed polyethylene bottles. They were then transported in a chilled esky for no more than 10 hours before being refrigerated or frozen, depending on the analysis.

Water samples were analysed for a range of physico-chemical factors, salts and nutrients that are listed in Table 1. An extensive quality control program was run in conjunction with routine sampling to ensure reliability of data collected. Instruments used to record data in the field were regularly calibrated and in-field checks were carried out to detect any instrument variations. At regular intervals, known quality control samples and blanks were submitted to check the accuracy and precision of the laboratory instruments.

Table 1: Laboratory analysis methods

Water quality variable	Analysis method
Physico-chemical data	
Temperature	In-situ measurement, YSI Model 63 probe
pH	In-situ measurement, YSI Model 63 probe
Turbidity	Hanna HI 93703 microprocessor turbidity meter
Suspended solids	2540 D*
Dissolved solids	2540 C*
Salt data	
Electrical conductivity	In-situ measurement, YSI Model 63 probe
Chloride	E1b**
Sodium adsorption ratio (SAR)	L1c, L2c, L4c, M1a**
Nutrients	
Total nitrogen	Alkaline persulphate digestion, 2400-NO3 F*
Total phosphorus	4500-P B(5), 4500-P F*

* Methods taken from APHA (1992)
** Methods taken from Rayment and Higginson (1992)

Flow measurements
River flow plays an integral part in the interpretation of water quality data. High flows tend to dilute concentrations; however, greater volumes of water carry greater quantities of salts and nutrients, i.e. higher loads. Due to the influence that flow has on water quality, the data in this report has been analysed within three flow phases based on mean daily flow at the twenty sampling sites; pre-watering (1st September – 30 November), irrigation (1st December – 31st March) and no irrigation (1st April – 31st August).

Discharge data was obtained from the NSW Department of Land and Water Conservation (DLWC) in Armidale and Moree. The flow data was collected to enable an estimate of daily loads of sediment, salts and nutrients that were added to the river system at various sites within the valley. By calculating loads at the sites located at the end of the valley, Site 18, Galloway and Site 20, Collarenebri, an estimate of the quantity of salts and nutrients leaving the Gwydir valley can be determined, and hence establish the Gwydir Valley's input to the Murray Darling Basin.

Water quality assessment
The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000) were used to assess water quality in the Gwydir Valley for the protection of aquatic ecosystems and irrigation water.

RESULTS AND DISCUSSION

Flow
Figure 2 shows the median daily flow at each sampling site, during each flow phase. The error bars represent the standard error of the median. Site 1 (Gravesend), 2 (Pallamallawa), 3 (Yarraman) and 10 (Moree) have a significantly higher flow compared to other sites within the valley. Site 1, located upstream of the irrigation area has a median daily flow of 2950 ML/day during the irrigation phase, compared with sites 18 and 20, located downstream of irrigation area, that have median daily flows of 168 ML/day and 90 ML/day respectively. This difference in flow between the upstream and downstream sites is because the Gwydir has not yet split into the Mehi and Carole anabranches at the upstream sites. The flows decrease through the valley as the Gwydir splits into these anabranches and with the extraction of water for irrigation and stock and domestic supplies, along with evaporation and seepage losses. Furthermore, environmental flows from natural

rainfall upstream or releases from Copeton Dam are accounted for in the flows at sites 1 and 2, but have no impact on flows at sites 18 and 20 as this water is directed straight down the Gwydir and Gingham watercourses (see Figure 1).

Flow during the pre-watering and irrigation phases are significantly higher than the no-irrigation phase with the release of water from Copeton Dam for irrigation purposes along with the increased likelihood of summer storms.

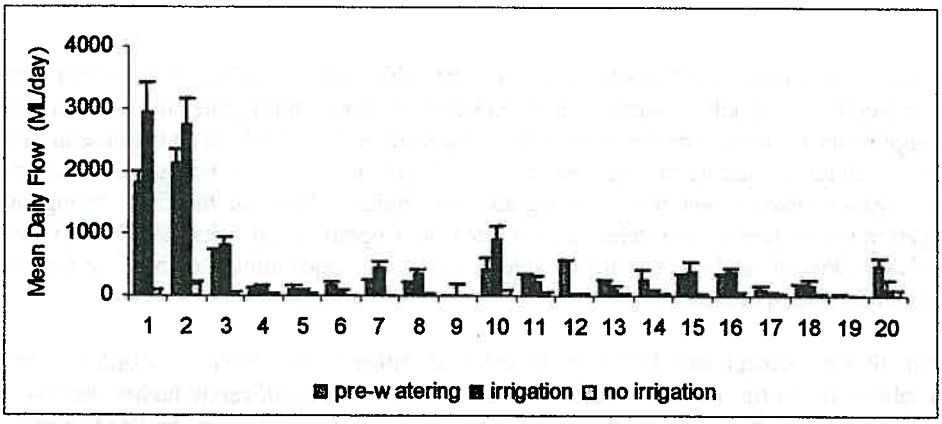

Fig. 2 Median mean daily flow for each river site, during each flow phase

Turbidity

Median turbidity of all sampling sites, within each flow phase is presented in Figure 3. All sites located downstream of site 10 (Moree) exceed the ANZECC & ARMCANZ (2000) water quality guidelines for protection of aquatic ecosystems (50 NTU) and irrigation water (100 NTU). Median turbidity increases along the valley, with the highest median values at sites located at the bottom of the valley, sites 17 (Iffley), 18 (Galloway) and 20 (Collarenebri). This is a reflection of the cumulative effects of landuse, streambank erosion and resuspension of sediments through the valley. The turbidity of water at site 9 is significantly higher than all other sites within all flow phases. This site is before any irrigation and is unregulated, therefore only flowing after runoff in the local catchment. Runoff, which causes soil erosion and therefore the transportation of particulate matter into the waterways, is a major contributor to turbidity.

High turbidity at sites lower in the valley reflect not only farming practices carried out on irrigated lands, which accounts for less than 4 per cent of the Gwydir Valley (North West Catchment Management Committee, 1997), but also landuse practices associated with dryland farming (26 per cent), grazing (58 per cent of the Gwydir), timber (12 per cent) and other landuse activities (< 1%) along the valley.

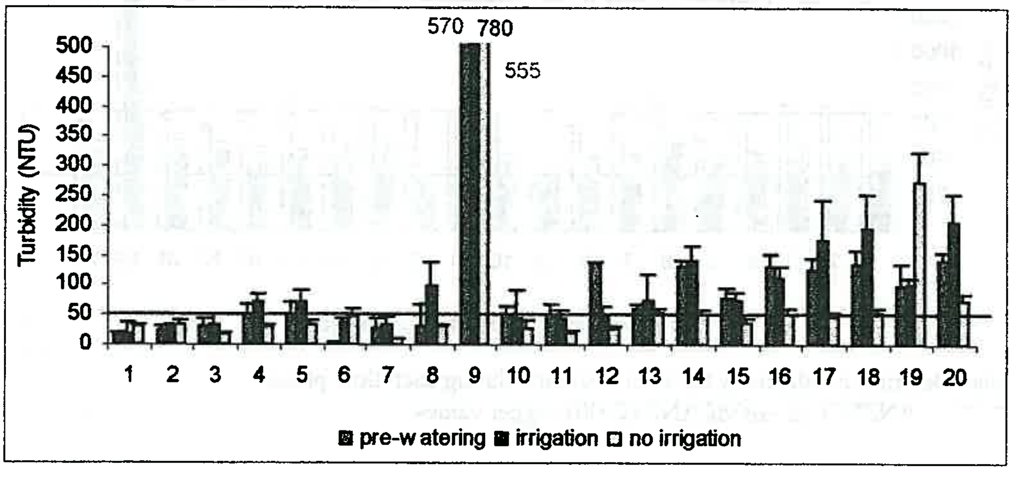

Fig. 3 Median turbidity for each river site, during each flow phase
——— ANZECC & ARMCANZ (2000) trigger value

Irrigators are required to contain all water (runoff and tailwaters) on-farm. Farms are designed to collect any water that runs off the fields and this water is stored in on-farm storages, which can be recirculated and used as irrigation water at a later date. Therefore, in theory, there should be no water coming off irrigation farms, and thus no input of sediments, salts and nutrients. However, during severe flood events, when farmers exhaust all water holding infrastructure, or during a collapse of irrigation infrastructure (channels, banks or storages), some water could be released off-farm making its way into the river system. It should be noted that during such a flood event, the water spreads over the vast flood plains, making it is impossible to determine the source of the sediments, salts and nutrients.

Salts

Median Electrical conductivity (EC) mostly exceeded the ANZECC & ARMCANZ (2000) water quality guidelines for protection of aquatic ecosystems (>300µS/cm), especially during the no-irrigation phase (Figure 4). EC has a significant negative correlation with flow (Nancarrow 1998), where an increase in flow causes a dilution of ions in solution resulting in a decreased EC. Therefore, EC is significantly lower during the pre-watering and irrigation phase when flows are significantly higher. Most of the flow during January and February (irrigation phase) comes from releases of water from Copeton Dam. Gordon (2001) found Copeton Dam water to have a low EC and releases from Copeton to have a major influence on EC in the Gwydir river system throughout the year 1999/2000.

Median EC for all sites except site 19 were classed with either a low (650 - 1300µS/cm) or very low (<650µS/cm) salinity rating for irrigation water. The EC at Site 19 is significantly higher than all other sites. This site is located at the end of the Gwydir River, where water only reaches during flood events, thus only flowing during flood events or local, runoff-producing rainfall events. It is a stagnant pond of water for most parts of the year where salts and nutrients accumulate and become concentrated due to the lack of fresh water flows, resulting in a high EC.

It can be seen that there is no significant increase in salinity moving downstream, indicating that irrigation is not influencing salinity in the rivers. Also, the release of irrigation water from Copeton Dam improves the salinity situation in the river due to the dilution effect causing a decrease in EC.

The median SAR for all sites within each flow phase are presented in Figure 5. The median SAR for all sites except sites 19 fall within a non-sodic classification (<3).

There is no significant difference between electrical conductivity (EC) and the sodium adsorption ratio (SAR) between the upstream (sites 1 and 2) and downstream sites (sites 18 and 20) within any of the flow phases.

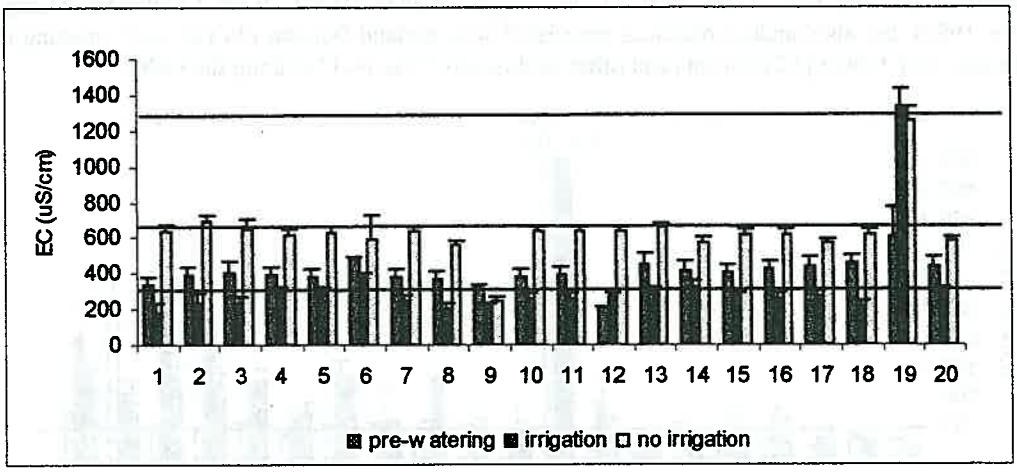

Fig. 4 Median electrical conductivity for each river site, during each flow phase
——— ANZECC & ARMCANZ (2000) trigger values

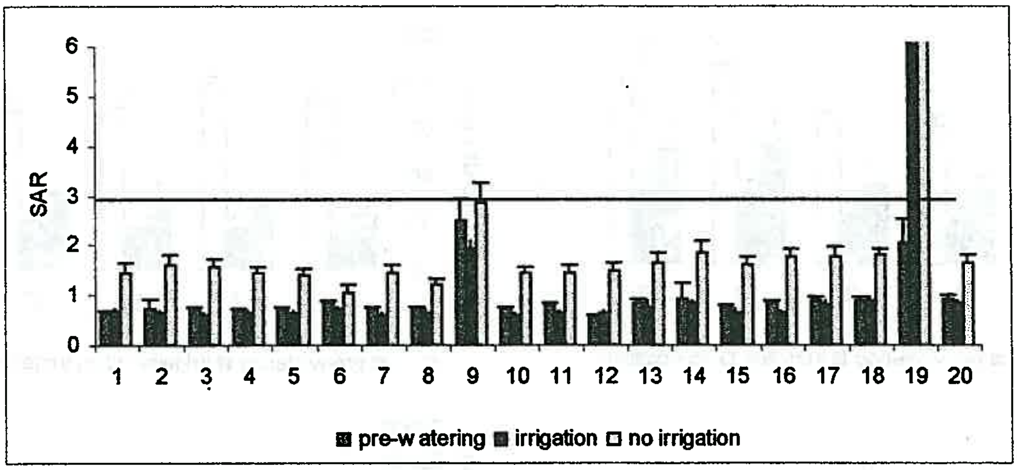

Fig. 5 Median sodium adsorption ratio (SAR) for each river site, during each flow phase
——— QDPI (1987) trigger value

Chloride levels at all sites fall below the level of chloride affecting sensitive crops (<175 μg/ml) as shown in Figure 6. Chloride levels are significantly higher during the no irrigation phase, as a result of the low flows during this phase.

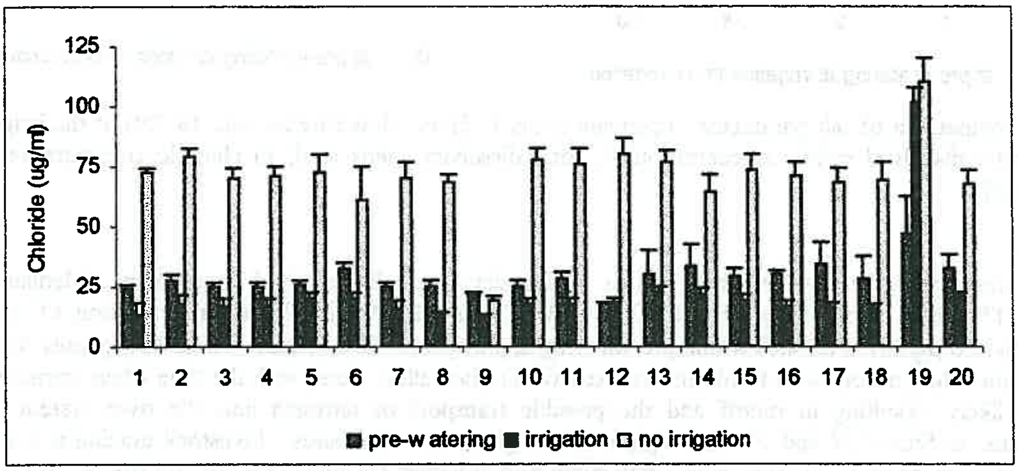

Fig. 6 Median chloride concentration for each river site, during each flow phase

Total dissolved solids (TDS) concentration is used as an estimate of salt concentration and consequently salt loads. Although there is no significant difference in salt concentration between the upstream and downstream sites, salt loads are significantly higher upstream as shown in Figures 7a and 7b. The median load of TDS during the irrigation phase for site one was 353 tonnes/day, whereas a median of only 35 tonnes/day flowed past site 18, and 23 tonnes/day flowed past site 20 in the same year. Again, although there is no significant difference in chloride concentration between the upstream and downstream sites, the loads of chloride (kg/day) are significantly higher upstream as shown in Figures 7c and 7d. The load of chloride in the water decrease with reduced flows downstream in the Gwydir Valley. The median load of chloride during the irrigation phase for site one was 27 tonnes chloride/day, whereas less than 2.5 tonnes flowed past both sites 18 and 20 in the same year.

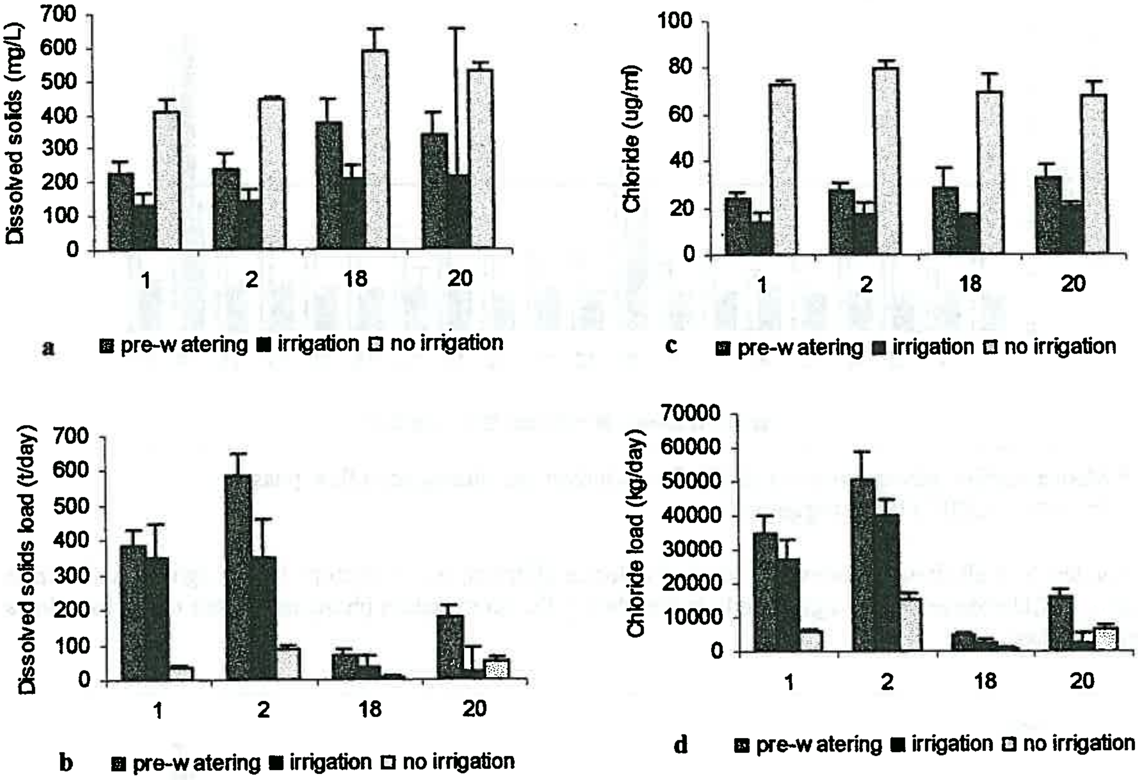

Fig. 7 A comparison of salt parameters, upstream (sites 1, 2) and downstream (site 18, 20) of the irrigation area. a) total dissolved solids concentration, b) total dissolved solids load, c) chloride concentration , d) chloride load

Nutrients

Figure 8 shows that the Gwydir River and its anabranches are relatively high in nitrogen. Median total nitrogen (TN) level exceeds the ANZECC & ARMCANZ (2000) guidelines for protection of aquatic ecosystems (0.6 μg/ml) at all sites within pre-watering and irrigation flow phases. These flow phases coincide with the time when nitrogenous fertilisers are used within the valley, along with the time when storm events are more likely, resulting in runoff and the possible transport of nitrogen into the river system. TN concentration at Sites 6, 9 and 19 were significantly higher than other sites. Livestock grazing is common around each of these sampling sites, which may contribute to higher TN concentration. All sites except site 19 meet the ANZECC & ARMCANZ (2000) guidelines for irrigation water (<5μg/ml).

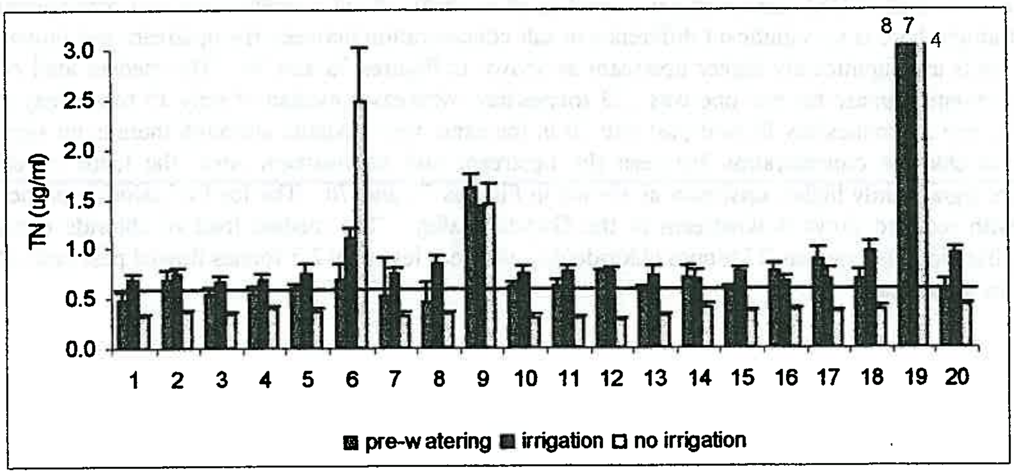

Fig. 8 Median total nitrogen for each river site, during each flow phase
——— ANZECC & ARMCANZ (2000) trigger value

Median total phosphorus (TP) at all sites exceeds the ANZECC & ARMCANZ guidelines for protection of aquatic ecosystems and irrigation waters (0.05µg/ml), as shown in Figure 9. Median TP is significantly higher during the pre-watering and irrigation phase for all sites except sites 6, 9 and 19. As phosphorus has a low solubility, it is rarely dissolved in runoff water, but is carried by suspended silt and clay particles (Mawhinney 1998). Sites 9 and 19 only flow during flood or local runoff producing rainfall events, therefore phosphorus would be carried into the river system bound to suspended sediment carried in the runoff water. Site 6 is located in the Gingham watercourse; grazing livestock that cause erosion to stream banks may be one factor causing higher TP levels at this site.

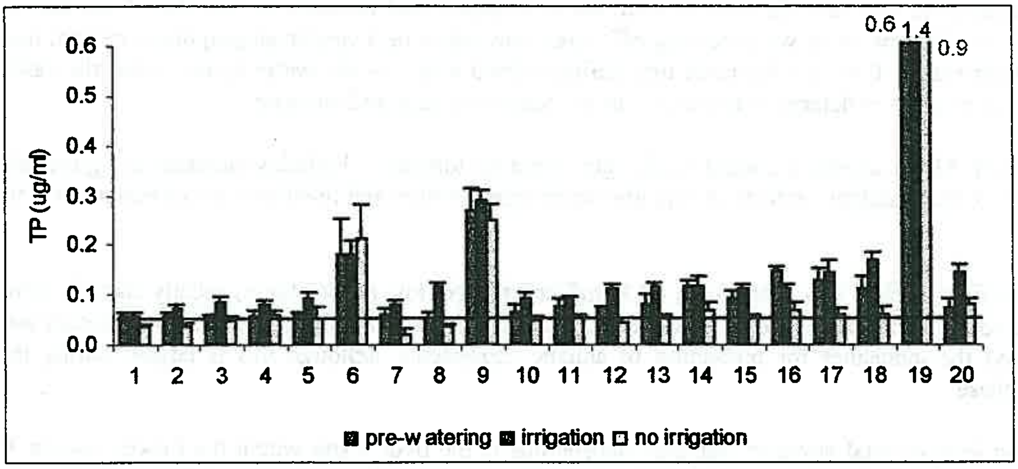

Fig. 9 Median total phosphorus for each river site, during each flow phase
——— ANZECC & ARMCANZ (2000) trigger value

The concentration of TN and TP is higher at the downstream sites. In contrast, the loads are significantly lower at the downstream sites compared to the upstream sites as shown in Figure 10. The difference in loads is a direct effect of different flows between the sites.

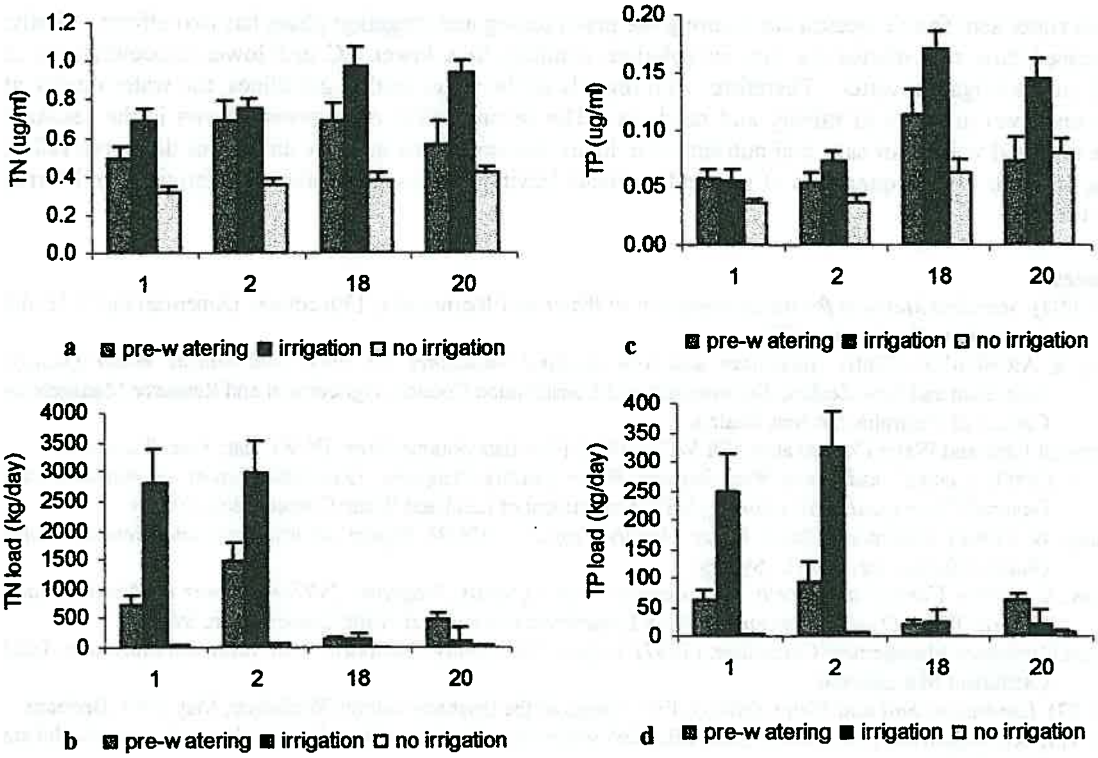

Fig. 10 A comparison of salt parameters, upstream (sites 1, 2) and downstream (site 18, 20) of the irrigation area. a) total nitrogen concentration, b) total nitrogen load, c) total phosphorus concentration, d) total phosphorus load

The median load of TN during the irrigation phase for site one was 2790 kgN/day, whereas a median of only 133 kgN/day flowed past site 18 and 103 kgN/day flowed past site 20 in the same year. This is similar to TP where the median daily load of TP was significantly greater at site 1 with 249 kgP/day flowing past this site, compared with only 23 kgP/day flowing past site 18 and 18kg P/day flowing past site 20 in the same year.

CONCLUSIONS

As irrigators are required to retain tailwater and runoff water on-farm, there should be little input of sediment, salts and nutrient from the irrigation industry. However, during flood events, some water could be released off-farm making its way into the river system, but as irrigated land amounts to less than 4 per cent of the Gwydir Valley, the amount of water coming off these farms would be a very small proportion of total runoff in a major flood event. It should be noted that during a flood event, as the water spreads over the vast flood plains, it is impossible to determine the source of the sediments, salts and nutrients.

All sites below Moree exceed the water quality guidelines for turbidity. Turbidity increases along the valley as a reflection of the cumulative effects of land use, streambank erosion and re-suspension of sediments along the valley.

River water falls within a low (650µS/cm - 1300µS/cm) to very low (<650µS/cm) salinity class for irrigation water. Although it meets the ANZECC & ARMCANZ (2000) water quality guidelines for irrigation water, it does exceed the guidelines for protection of aquatic ecosystems, although this is largely during the no-irrigation phase.

The median level of total nitrogen and total phosphorus in the river water within the Lower Gwydir Valley exceeds the ANZECC & ARMCANZ (2000) water quality guidelines for protection of aquatic ecosystems.

The strategy of recirculating water and containing tailwater and runoff on-farm appears to be preventing higher loads of nutrients, particularly nitrogen, from entering the river system. However, in times of exceptional flooding and inundation some contamination will occur. However, it is not possible to say that the elevated levels of nutrients in the rivers are a result of irrigation.

Irrigation water sent from Copeton Dam during the pre-watering and irrigation phase has two effects. Firstly, the increased flow rate dilutes the ions in solution, resulting in a lower EC and lower concentrations of nutrients in the irrigation water. Therefore, with regards to the water quality guidelines, the water quality at all sites improves in terms of salinity and nutrients. The second effect of increasing flows is the resultant increase in actual volume of salts and nutrients (i.e. load). However, this quantity diminishes down the valley, resulting in much smaller quantities of salt and nutrients leaving the Gwydir Valley and entering the Murray Darling Basin.

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