Executive Summary

This document captures our current understanding of groundwater quality, quantity and interaction with rivers. The Namoi catchments are some of the most extensively studied catchments in Australia and the World. But there are still many gaps in our understanding of groundwater which limit our capacity to manage how we allocate between all stakeholders including rural industries, mining, urban users and the environment. To allow for a better informed discussion on groundwater usage improvements are needed in the science underlying catchment management.

Estimating catchment scale water fluxes is not an exact science. There are errors in estimating rainfall recharge, river recharge, irrigation returns to the aquifer, inflows through basement rocks, discharge via the rivers, evapotranspiration losses, surface water storage losses, and quantifying flood events. This is why catchment water balances have to be modelled and best estimates given (ideally with confidence intervals). Through improved measurement techniques, higher resolution data and advancement in numerical computer modelling techniques the errors associated with quantifying water fluxes through the catchment can be reduced and water management decisions improved. In some cases the quality of the data can be improved easily, for example the density of rainfall gauging stations is too low for catachment water balance modelling, and borehole water levels should be recorded more than 4 times per year. In stark contrast to these quarterly borehole measurements, in the USA daily borehole water levels are reported on the web for over 4000 wells throughout the country.

There are many unanswered questions about the extent of interaction between surface and ground waters, and the long term trends on water quality and the impacts on the environment. Although considerable work has been undertaken in the past this work has not been systematic with respect to groundwater quality.

Current water balance models need to be updated. In particular there needs to be improved modelling of surface and ground waters as a connected resource. This has significant implications with respect to current management practices which separate surface and ground waters. An enhanced understanding of the interactions between rivers and aquifers would help in determining what water management decisions need to be made in order to achieve current environment goals and end of valley targets.

Listed below are recommended projects that will advance our scientific understanding of the aquifers in the Namoi catchments.

- Measure the trends in water quality from irrigator bores.

  Saline water overlies the fresh water intervals used for irrigation water. Some of this saline water approaches sea water salinity levels. Under heavy pumping and in areas where aquifer water head level is declining, the saline water is moving towards the fresh water zone. We have limited understanding of the rate of migration of the saline water. We need to understand how bore water quality changes throughout the season.

  There is the potential in some districts that in the longer term irrigation water quality may decline with respect to salinity levels or its sodium adsorption ratio (SAR). Both would have a detrimental influence on crop yields.

- Measure trends in water quality using the Department of Natural Resources (DNR) groundwater monitoring network.

Measuring water quality using the DNR groundwater monitoring network boreholes is a larger project compared to using irrigator boreholes because each monitoring bore needs to be pumped prior to taking measurements.

At least some key locations need to be analysed, because our only publicly available water chemistry records exist for the DNR monitoring boreholes.

- The surface and ground water chemistry of the Cox's Creek, the Upper Namoi and Peel catchments needs to be systematically studied.

There are indications that some of the highest salt concentrations come from these regions. This would be a suitable PhD or Postdoctoral investigation along the lines of McLean (2003) and Lavitt (1999).

The data set by Lavitt (1999) needs to be reanalysed with respect to irrigation water quality and the impacts on soil health and crop yields.

Major ion chemical evolution studies are needed in the Peel River and Cox's Creek catchments. Data from the soft and hard rock regions are needed as part of these investigations. The water chemistry also needs to be analysed with respect to long-term soil health and crop yields.

- Record deep drainage at the shallow water table.

Better estimates of deep drainage are needed and deep drainage needs to be incorporated into regional surface and ground water models. Current deep drainage research is focused on how much water passes the root zone. In addition to this, we need measurements of the shallow water table response throughout the growing season. We need to know how much water reaches the shallow groundwater systems and then how much reaches the deeper aquifers that are used for irrigation or moves laterally to the rivers.

At the moment deep drainage is not allocated as an input in the sustainable groundwater yield model of the Lower Namoi. A quick calculation for the Namoi shows that this is a significant gap in our understanding of the water accounting. Assuming 52,000 hectares of cotton (Cotton Australia 2005) is grown using 7 ML water per hectare and that 10% of this water goes to deep drainage, then 36,400 ML of recharge heads towards the aquifer. This deep drainage recharge is not part of the current water budget calculations. To put this into perspective, this is 17% of the recharge estimates for the combined Upper and Lower Namoi (NSW DSNR, 2003).

- Recharge and discharge zones along the rivers and streams need to be mapped.

Geophysical surveying using a combination of temperature and electrical resistivity imaging would highlight priority areas for more detailed investigation. This work would complement the goals of managing connected water resources and conjunctive water management (refer BRS, 2005; IAH, 2004 and Fullagar, 2004).

Based on the priority areas from the geophysical surveys detailed water chemistry needs to be undertaken.

The UNSW Maules Ck project is achieving this goal for one small stream. This style of work needs to be extended along the Namoi River.

- Incorporate farmer recorded rainfall data into water balance models.

The rainfall gauging network used by the Bureau of Meteorology for recording rain is too coarse, resulting in substantial uncertainty in the rainfall contribution in catchment scale water balance modelling. Incorporating farmer recorded rainfall data into regional water balance models would improve the uncertainty in this variable. This is particularly important near the catchment boundaries where there is orographic rainfall and recharge zones for the alluvial aquifers, but very few nearby rainfall gauging stations.

- Compare cumulative rainfall departure data with DNR monitoring bore hydrographs.

A comprehensive statistical analysis is needed comparing rainfall trends to groundwater behaviour. From this analysis index maps can be developed to determine where aquifer behaviour is in or out of sync with respect to prevailing climatic conditions. A long range predictive tool can also be developed from this analysis.

- Compare data from irrigator boreholes with nearby DNR monitoring records.

Numerous irrigators commented that the information reported by DNR does not match their personal observations. There are many possible reasons for this including: bores slotted into different aquifers within the alluvial sediments, maintenance history of both irrigator and DNR bores, static wells versus pumped wells, and the potential for artificial connection between upper and lower aquifers depending on how the wells were installed.

- Develop a best practice approach to water allocation modelling.

Current groundwater models which are used as part of the sustainable groundwater yield estimates are created using MODFLOW. This software does not model surface water inputs comprehensively. IQQM, which is used for surface water estimates, does not model groundwater contributions sufficiently. Present IQQM and MODFLOW models for the Namoi have a disagreement in water flux at the boundary.

Irrigators want to know that the best available approaches have been used, and that the uncertainties in the allocated volumes are characterised. The best available approach now is to use coupled surface and ground water modelling.

It is now possible to couple surface and ground water modelling using several commercially available software packages. Queensland NRM has already applied this approach in coastal regions, but not in catchments of interest to the CRC. Coupled modelling has not been undertaken by NSW DNR. Provided there are sufficient flows in Cox’s Creek in the next couple of years, the Cox’s Creek modelling project will demonstrate part of the methodology. However, to show the flexibility of the approach, coupled surface and ground water modelling needs to be undertaken in another region.

- Couple the groundwater chemistry to the groundwater flow modelling.

To better understand the migration of zones of saline groundwater towards the fresh water zones the water chemistry needs to be coupled to the groundwater flow models. However, in order to be able to couple the water chemistry to the groundwater flow modelling, a higher resolution MODFLOW or FEFLOW model of the catchment needs to be constructed. Higher resolution models are required to better capture the geological complexity of the aquifers.

- Explore the reuse of deep drainage water.

In areas where the shallow groundwater is rising due to deep drainage, the re-use of the water could be explored. This assumes the shallow water is not too saline and the quantities are economically viable.

- Areas of rising head levels in the Gunnedah Formation need to be investigated within the context of the Water Sharing Plans.

The Water Sharing Plans for the Namoi do not adequately address areas of rising groundwater head levels. Further work is needed to characterise the extent of rising groundwater head levels, and how to best balance these areas in water allocation decisions.

- Examine the potential for artificial recharge.

It has been shown that the construction of the levee banks and floodways in the Lower Namoi has enhanced the recharge to the aquifer. This was not done by design. Thus there exists the potential to optimise the design of the levees and floodways to further enhance recharge to the aquifer under major flood events. (Note: this would have to be balanced with environmental and flood plain considerations downstream)

- Quantify the impact of the proposed coal mines on groundwater allocations and water quality.

While is it the responsibility of the coal industry to develop environmental impact statements for any future developments, the cotton industry in association with other industries and organisations needs to undertake its own evaluation so that an informed debate can take place.

- Benchmark conditions for the Water Sharing Plans.

DNR has responsibility on behalf of the Minister to benchmark conditions as part of the Water Sharing Plans. Through the Cotton Catchment Communities CRC all stakeholders could accelerate the rate and extent of benchmarking of groundwater quality, groundwater dependent ecosystems, and whether intervals of the rivers and streams are gaining or losing sections. This would benefit all stakeholders when the Water Sharing Plans are reviewed.

- Build a 3D model of the hydrogeology of the Namoi catchments to reduce management errors.

Most petroleum basins and many industrial contaminated sites have had 3D Geological Models constructed to display in a single environment all the data known about the area of interest. From the information reviewed for this report there are enough data to be able to build a 3D model of the surface and ground waters of the Namoi aquifers. This would provide an important aquifer management tool coordinating all sources of data and help as a communication tool in public forums.

- Develop a correction for sediment load on river electrical conductivity measurements.

A correction is needed for the sediment load in the river water when measuring electrical conductivity to determine river salinity and salt load levels. At the moment no correction is being made for high cation exchange capacity clays in the water. These clays would contribute to the electrical conductivity of the water, resulting in the overestimation of salt loads.