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On TRaCK

Tropical Rivers and Coastal Knowledge

Natural flows support healthy rivers in the north

By Jenni Metcalfe

Sixty river systems drain the catchments of northern Australia's wet-dry tropics, flowing with the changing rhythms of the seasons and largely unchanged since European settlement.

There are only 27 large water storages (greater than 0.2 gigalitres) in northern Australia compared with 467 storages in the south. This reflects that less than two per cent of the land is used for production forestry, cropping, horticulture and mining.

The intact nature of tropical rivers means that researchers can find out—more effectively than for the modified rivers of southern Australia—how these rivers naturally function to sustain the rich diversity of plant and animal life characteristic of, and often unique to, this part of the world.

Looking at what drives the healthy ecology and functioning of tropical rivers has been a focus for TRaCK research. This knowledge will assist the management of these tropical rivers as well as more modified systems elsewhere.

'The knowledge gap with rivers is always about what flows are essential to keep the whole system functioning', says TRaCK researcher Dr Danielle Warfe from Charles Darwin University.

Patterns in river flows the key to river function

Over the course of the past three years, TRaCK research found that the distinctive flow patterns (see Figure 1), driven by the marked wet and dry seasons typical of the north and the transition periods between the seasons, are the major influences on how tropical rivers function.

River flows are further affected by rainfall variability from year to year, and also between catchments, which together affect the size and duration of wet-season floods. Some areas are flooded for months while others are flooded for only days or weeks at a time.

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Photo: Ian Dixon

The wet season stimulates aquatic plant growth on floodplains such as this one in Kakadu National Park.

In this issue

During the wet season, aquatic plants such as the native lotus (*Nelumbo nucifera*) grow rapidly on floodplains such as Yellow Waters, Kakadu. Photo: Jenni Metcalfe

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TRaCK brings together leading tropical river researchers and managers from Charles Darwin University, Griffith University, The University of Western Australia, CSIRO, James Cook University, Australian National University, Geoscience Australia, Environmental Research Institute of the Supervising Scientist, Australian Institute of Marine Science, North Australia Indigenous Land and Sea Management Alliance, and the governments of Queensland, the Northern Territory and Western Australia.

Foreword

Professor Michael Douglas
TRaCK Research Director

Welcome to the fifth issue of *On TRaCK*.

As the north heads into another wet season, southern Western Australia continues to face crippling drought while much of the southern states experience above average rainfall. Inevitably, when things dry out down south many people will again turn their attention to the seemingly limitless water resources of Australia's tropical rivers.

The knowledge we have collected over the past four years makes it clear that, though we have abundant water resources during the wet, it's a very different picture during the rest of the year.

Most of the north's rivers dry up completely during the dry season, some of them receding to isolated pools of water. The stories about river flows and waterholes in this issue of ***On TRaCK*** show how important the scarce water remaining in these waterholes is for the animals that seek refuge there until the following wet.

The few rivers that keep flowing through the dry, such as the Daly River in the Northern Territory, are fed by groundwater. Their dry-season flows are essential for allowing barramundi and other fish species move up and down the river to feed and breed.

The importance of understanding the interactions between ground and surface water is highlighted in the story about our work engaging communities in water planning in the Howard East region, south-east of Darwin. Participatory water planning is crucial for getting communities involved and giving them ownership in plans that directly affect them, while also requiring them to consider what they value about their water resources.

Any water-planning or water-trading scheme needs to meaningfully involve Aboriginal people, as demonstrated by our research on water markets in the north, also covered in this issue. And our story about recording the changes to rivers as observed by Aboriginal elders in the Fitzroy and Mitchell River catchments shows how Aboriginal knowledge can complement scientific knowledge while also helping Aboriginal communities record their knowledge and heritage.

After four years we are nearing completion of this first phase of TRaCK and we are already seeing some really exciting outcomes. We are looking forward to continuing this journey as we find new knowledge important to river managers and users.

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Australian tropical rivers show three different 'regimes' of flow. Most common are those rivers that flow intermittently; they flood in the wet season and then slowly dry out completely or contract to a series of waterholes in the dry season. Less common are inland rivers adjacent to desert areas which stop flowing for long periods of time. The third type of flow regime, which is rare, is perennial and these rivers flow all year round. The Daly River in the Northern Territory is perennial; during the dry season it is fed by groundwater.

'A river's flow regime affects how different habitats connect with each other over space and time', says Dr Warfe. 'Flows connect habitats along a river from the headwaters to the mouth. They can also connect habitats across a river, from the river channel to riverbanks and onto floodplains. And they can connect habitats vertically, from the water surface to the river sediments and to aquifers deep beneath the river bed.

'These connections change with the seasons and have a huge effect on what animals and plants live where, and when they become important in how a river functions.'

Wet-season flood duration sets the scene for the following dry season

The high flows of the wet season shape the rivers and floodplains, transport nutrients and sediments and reconnect habitats along a river, allowing animals to move up, down and across a river system. For example, barramundi and crocodiles use wet-season flows to move between estuaries and the river, and between the river and the floodplains.

Floodplains such as those in Kakadu National Park and on the Daly River almost always flood in the wet, and can be inundated for up to many months at a time. Others, like the Mitchell River in Queensland and the Fitzroy River in Western Australia, do not flood every year and when they do the floods usually only last for days or weeks. The variation in flood duration can set the scene for the make-up of floodplain communities into the following dry season.

'Short flood periods limit abundant plant growth to permanent waterholes and there's less opportunity for aquatic animals to move through the river and re-populate different reaches', says TRaCK researcher Dr Neil Pettit from the University of Western Australia. 'Longer floods provide an opportunity for floodplains to boost plant growth.'

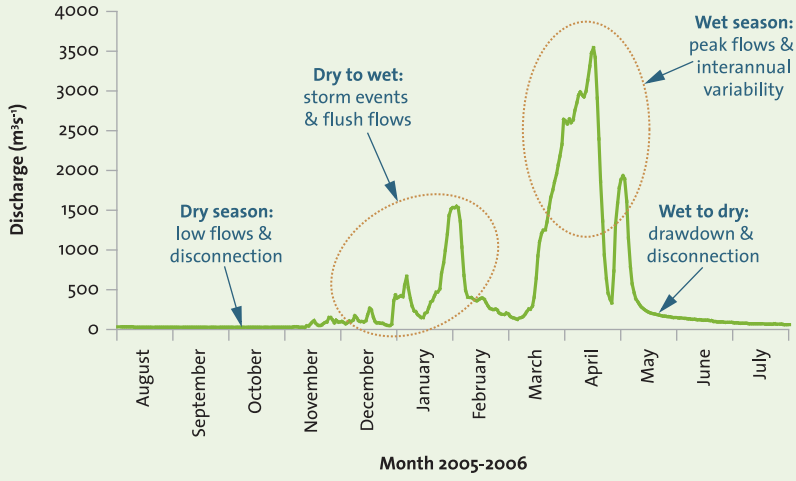
The inundation of floodplains brings major changes to the plant communities. In Kakadu National Park, the isolated waterholes of Magela Creek floodplain are dominated by algae during the dry season, but larger aquatic plants which flourish on the inundated floodplain take over during the wet season.

'While these larger plants are not used as food by aquatic animals, they provide habitat for invertebrates and bird nesting sites, and food for birds and other land-based animals', says Dr Pettit.

Neil Pettit (left) and Danielle Warfe record and measure catches from nets set at the end of the dry season in the Fergusson River, a tributary of the Daly River, in the Northern Territory.

Photo: Jenni Metcalfe

Figure 1: The pattern of flows in the Daly River in 2005–06 illustrates the strong effect of the seasons on river hydrology.



These larger aquatic plants also provide habitat on the floodplains for algae, which attach themselves to the plants. Algae are important because they drive most of the aquatic food webs.

Seasonal freshwater floods also affect estuarine and coastal animals. More prawns and barramundi are caught during years of big floods, and the growth and development of barramundi and king threadfin salmon rely on both the size and timing of wet-season floods.

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Wet-to-dry transition period sees animals on the move

During the transition time between the wet and dry, larger aquatic plants grow rapidly on floodplains that have been inundated for some time, and algal growth at the bottom of rivers booms as the water becomes clear and recedes.

'This is a key time for the large-scale movement of animals', says Dr Warfe. 'But animals such as fish are not necessarily moving to spawn or reproduce; they are possibly looking for suitable permanent waterholes to wait out the dry.'

Saltwater crocodiles that have spread out across the floodplain now retreat to the main river channels. Waterbirds such as darters, cormorants, pelicans and grebes gather around waterholes as the water contracts to feed off insects and prey fish, which are in abundance.

'In Kakadu, for example, magpie geese are commonly seen on floodplains that have been inundated for a long period of time', says Dr Pettit. 'They congregate around waterholes where they can use the larger aquatic plants to nest and feed.'

Dry season disconnects water resources

During the dry, most tropical rivers dry out completely or contract into isolated waterholes on the floodplains and river channels. These waterholes are now critical for sustaining animal and plant life.

'We found there is considerable variation between the productivity of waterholes', says Dr Warfe. 'Some are naturally cloudy and support only algae, which might be restricted to the edges or possibly throughout the water. Others have deep, clear water and support a range of plants and animals.'

During this time, fewer species of fish are found, especially in intermittent rivers, and their diet becomes narrower as the range and abundance of food diminishes.

In the few rivers where groundwater provides ongoing flows to keep them running, such as the Daly River, the water becomes clearer during the dry but has less nutrients. The shallow reaches of these rivers, which flow over rocky outcrops, provide critical refuges for numerous species during the dry season. Juveniles of some fish species, such as sooty grunter, use these habitats where they are safe from predation by larger fish species. These areas also provide habitat for aquatic invertebrates and algae, the latter being an important energy source supporting river food webs.

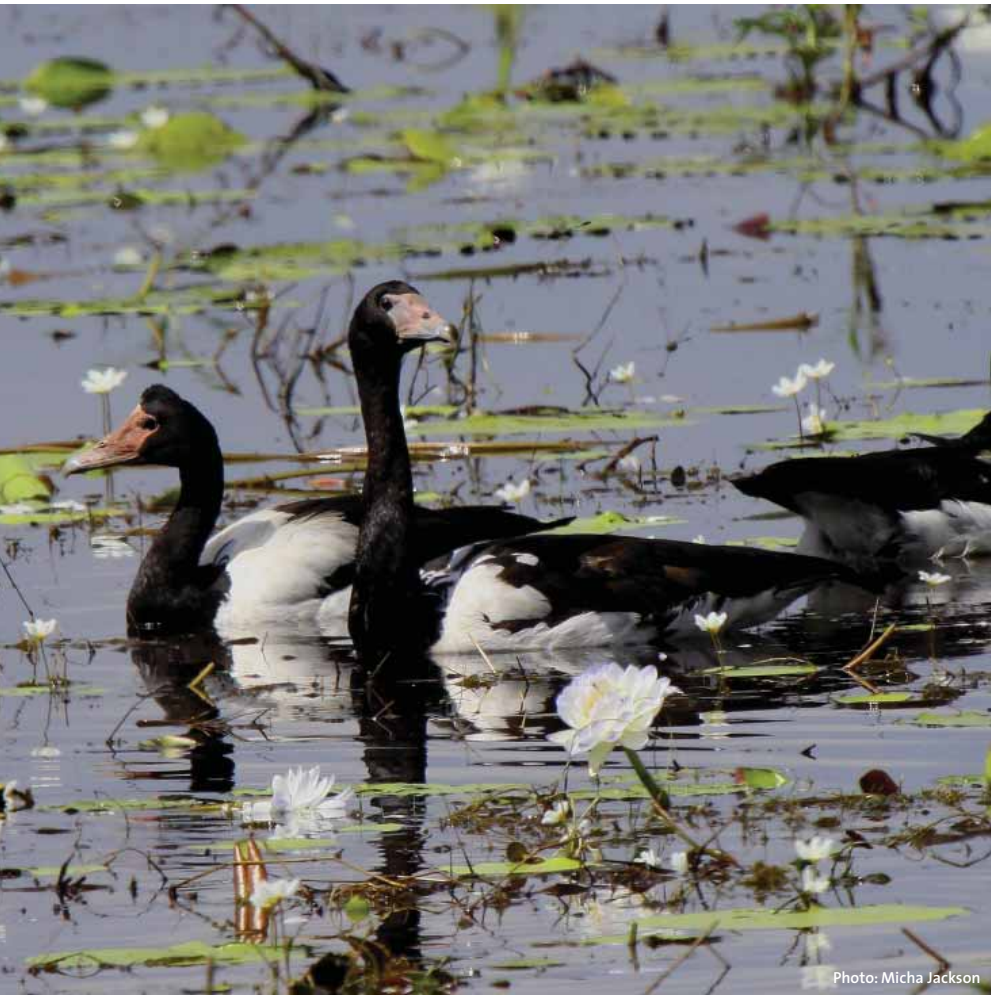
Dry-to-wet transition period reconnects rivers

The first flows of the wet season reconnect and flush out waterholes where water quality has deteriorated over the course of the dry season; this can lead to a pulse of poor-quality water moving down the system, which can occasionally kill fish. But subsequent flows provide an opportunity for fish and other animals to leave the waterholes and re-populate more favourable parts of the river.

The early wet season is an important time for crocodiles to move again through the river systems and into floodplain waterholes. Juvenile barramundi start to swim upstream from the estuaries to the floodplains and river tributaries, and freshwater prawns can be seen 'marching' upstream in large numbers at this time of year.

Implications for river managers

'Different river flows throughout the year are important triggers for the movement, growth and reproduction of many plants and animals', says Dr Warfe.



Magpie geese (*Anseranas semipalmata*)

'The wet season is rich in nutrients and food, but animals and plants need to be able to respond to transition periods and move throughout the river system to places where they can survive. They then need to be able to withstand the dry season. If we alter the natural flows, this could have far-reaching consequences."

Dr Warfe believes it is important for river managers to look at what flows are essential to keep the whole river system functioning.

Water managers in the Northern Territory provided information on tropical river flows to TRaCK researchers so that they could use their research on food webs and flows to analyse the likely impacts of any changes to those flows.

'We are interested in the impacts of changing flows on both the natural and social environments', says Ian Lancaster, Director of the Water Resources Branch of the Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS).

'It is not only important to protect the natural environment; we also need to make sure Indigenous communities have access to their important river food sources. If we know the likely impacts of changing flows, we can seek to minimise these impacts.'

As a consequence of TRaCK research, NRETAS has capped groundwater extractions from the Oolloo aquifer which discharges water to the Katherine and Daly Rivers, keeping them flowing during the dry season.

'The later dry-season flows are made up entirely from groundwater and TRaCK research shows that if we reduce these too much they could impact on levels of sooty grunter and barramundi fish populations', says Mr Lancaster.

'TRaCK research has also shown that these are important indicator fish for the health of the whole river system. There are 47 species of fish in the Daly River and its tributaries, and we can't possibly hope to monitor them all, so this is important information.'

Dr Warfe also believes TRaCK's characterisation of natural tropical river flows will help save water managers from having to conduct detailed studies in each catchment.

'River managers can now go to a new catchment, work out the flows typical of this catchment and then have a better idea of what is required to maintain the health of that river system.'

This is a critical advance given that the pace of new water use outstrips the ability of researchers to conduct the sort of detailed studies that TRaCK has carried out over the past three years.

Peter Kyne (left) and Danielle Warfe set up fyke nets in the Edith River, Northern Territory.

Photo: Michael Douglas

Waterholes evaporate over the long dry season. This one is fed by the Flinders River during the wet season.

Tropical waterholes – fragile and valuable refuges

By Sarah Cole

Photo: Jonathan Marshall

The wet season, between November and March, dumps up to 200 mm of rain a month on Queensland's Flinders River catchment which drains into the Gulf of Carpentaria. Eighty-nine per cent of the catchment's rainfall occurs during this period.

In April, the rains drop off sharply and, in spite of the cooler weather, rivers slowly evaporate leaving disconnected pools of water. These waterholes are not topped up from below by groundwater—they only fill when the river flows, and during floods. Many of them dry up completely before the wet season starts again.

More than 90 per cent of Australia's 3.5 million kilometres of lowland rivers flow for only part of the year. Most of these rivers are in northern Australia.

During the dry season, the rivers' waterholes are critical refuges for plants and for animals such as fish, turtles, prawns, crocodiles, freshwater mussels, and rare and endangered species such as sawfish and freshwater stingrays.

Juvenile barramundi swim upriver before the floodplains dry out, sheltering in waterholes for up to four years while they mature.

'In rivers that stop flowing in the dry season, waterholes are the only remaining habitat, and source of food and water', says TRaCK researcher Dr Jonathan Marshall from the Queensland Department of Environment and Resource Management.

When the rains begin again, animals and plants from those waterholes that persisted through the dry season repopulate the rivers.

Waterholes are also highly valued as recreation and tourism spots. Punchbowl Waterhole, near Julia Creek on the Flinders River, is a popular family area for fishing, swimming and picnicking.

Pressure on the north's waterholes is mounting due to increasing water demands, uncontrolled access by livestock, fishing, and climate change. TRaCK researchers have been studying how waterholes function and finding out how to best protect them. This knowledge is essential for landowners, resource managers and water planners who need to understand the consequences of changing water and land use in the north.

Waterhole habitats are vulnerable to changes during the dry season

To understand how waterholes work, the researchers mapped the health of waterholes in the Flinders River catchment. They measured chemical properties such as levels of nutrients and oxygen, and physical properties such as turbidity (or cloudiness) and chlorophyll levels. They found that over the dry season many of those properties changed.

'Waterholes at the end of the dry season are very different to what they are like at the start of the dry season', says Dr Marshall. 'They become shallower, smaller, the water chemistry changes, and food availability changes.'

Grazing animals, erosion, fluctuating oxygen levels and predation contribute to these changes.

Cattle and feral pigs come to drink at waterholes during the dry season, disturbing soil in the water and making the water more turbid, or clouded. 'When animals wade through waterholes, they cause a lot of physical damage, changing ecological processes that support aquatic organisms', says Dr Marshall.

Erosion also changes waterholes. When animals trample across the banks of a waterhole, the eroded soil from the banks makes the waterhole shallower, which can reduce how long the waterhole survives in the dry.

Shallower water can also lead to toxic blue-green algae blooms and dangerously low oxygen levels at night, forcing some fish species to reduce their activity, including feeding.

Nutrient levels restrict the growth of algae in waterholes

Nutrient levels are one of the few properties that do not change much over the dry season. Concentrations of nutrients such as nitrogen and phosphorus are usually low in Flinders River waterholes. Even flooding of nearby land does not add many nutrients because the soils are naturally low in nutrients.

TRaCK researchers found that the growth of algae in waterholes is restricted by a lack of nutrients—not by a lack of light caused by turbidity.

'We found that when we added more nitrogen to the water, this stimulated more algal growth', says Stephen Faggotter, a TRaCK researcher from Griffith University.

Algae are the primary foodstuff produced in waterholes. Small fish, such as bony bream and catfish, feed on algae and are in turn eaten by larger fish such as barramundi.

The entire food web relies on a continual supply of algae.

The sensitivity of algal growth to extra nutrients in waterholes means catchment managers have to carefully monitor nutrient inputs to rivers. Extra nitrogen will increase the growth of some types of algae. Extra phosphorus, which has also been found to limit algal growth, may lead to blue-green algae dominating waterholes, which can reduce water quality and lead to fish kills.

Tropical waterholes differ between rivers and within the same river

Waterholes vary from river to river across the north. Turbidity varies, affecting which plants grow in the waterholes, which in turn affects the food webs, including the abundance of fish species.

Even in the same river, waterholes can vary a lot. 'Things like climate, water quality, how porous the soil is, can mean waterholes on the same river aren't identical', says Dr Marshall.

Some waterholes are shallow and short-lasting, others deep and permanent.

'Waterholes on floodplains are only connected by floods big enough to link them, but waterholes in a river channel connect up whenever the river flows. This changes whether animals can move between waterholes, and when they move.'

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A floodplain waterhole on the Mitchell River, Queensland

Photo: Jonathan Marshall

The Flinders River catchment, Queensland

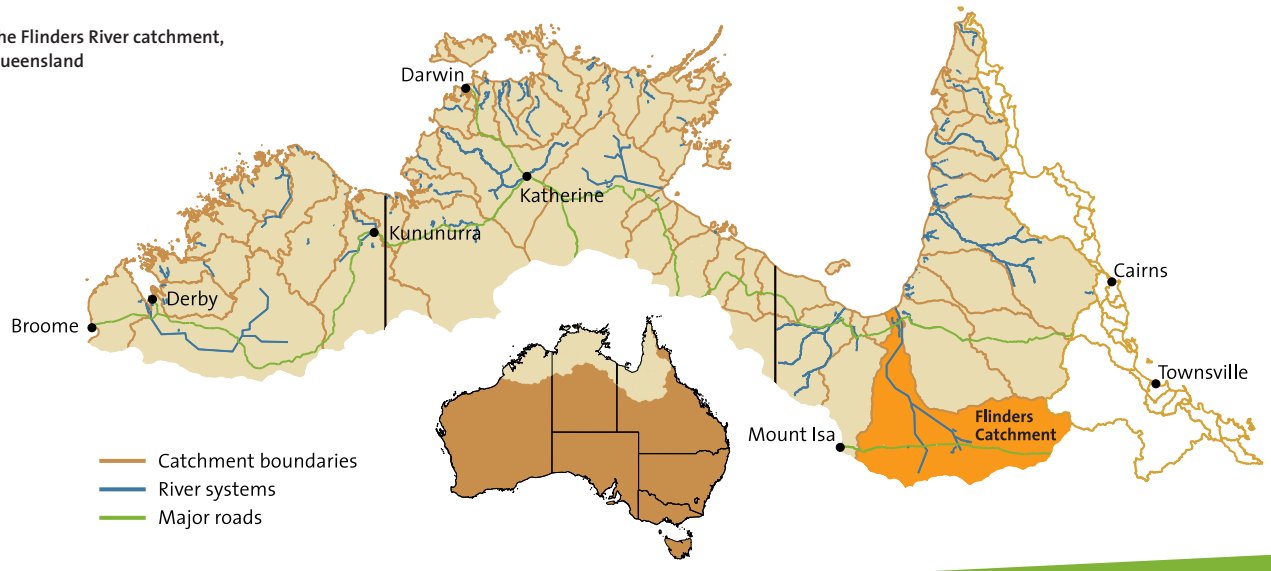

Photo: Jonathan Marshall

Crocodiles are one of the species that wait out the dry season in waterholes on the Flinders River.

'Of course, we would like to eventually be able to take some water for irrigation, but if the existing waterholes couldn't handle it, I would never do it. We want to look after the environment and waterholes more than anyone. Most landholders would like to see them maintained.'

TRaCK research is informing water-resource planning

TRaCK researchers stress the importance of monitoring northern rivers so that changes can be detected early. **Changes in waterholes can upset the balance of the ecosystems relying on them, from algae all the way up to barramundi and crocodiles.** The researchers are working with traditional owners and state agencies to develop tools for monitoring rivers and waterholes.

Cattle grazing in the Mitchell River, Queensland

Photo: Natalie Stoeckl

This Flinders River waterhole may support barramundi, crocodiles, prawns, mussels and turtles.

Photo: Jonathan Marshall

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Water extraction threatens Flinders waterholes

As urban and agricultural development expands, the risk that water extraction poses to waterholes escalates. Reduced water flows magnify the harshest conditions of the late part of the dry season.

'Future development which extracts water from the waterholes will threaten the abundance and diversity of fish and other life', says Stephen Faggotter. Flinders River waterholes are not fed by groundwater, so this is a particular concern for the river's plants and animals.

Grazier Ray Jansen runs 45,000 cattle on properties near Cloncurry, within the Flinders catchment. One of these properties has four semi-permanent waterholes.

'The water quality in our waterholes is usually pretty good', says Mr Jansen.

'Monitoring is prioritised based on the level of threat which a waterway is exposed to', says Dr Marshall. 'Any threats to waterholes, such as to how long they last, the water quality, or habitats, can endanger local populations of fish and other aquatic species.'

TRaCK's research into waterholes will help resource planners developing the Queensland Gulf Rivers water-resource plan. 'It's also relevant to much of Australia', says Dr Marshall, 'because it's giving us an understanding of the ecology of rivers with temporary flows.'

Aboriginal elders share their river stories

By Jenni Metcalfe

Traditional owner Esme Grainer (centre) shares the changes she has seen in the Mitchell River, accompanied by her daughter Estelle Waia (left) and TRaCK researcher Hmalan Hunter-Xenie (right).

Photo: Tony Hill, ABC

‘Some places on the river you see are clean, while the water is turning green in other places, and the water, like the main living water, is getting shallow. Why is that? We want to really look, to be careful.’

Mervyn Street, a senior Gooniyandi man, is talking about some of the changes to the river on his country, about two hours east of Fitzroy Crossing in the Kimberley in northern Western Australia. Mr Street is one of the Aboriginal elders who took part in an oral-history project with TRaCK, which recorded their observations of changes to rivers and wetlands in the Fitzroy River (Mardoowarra) catchment in the Kimberley and the Mitchell River catchment in north Queensland.

Oral history augments scientific knowledge

The project’s overriding aim was to gather Indigenous knowledge to complement scientific knowledge about how the rivers are changing and to help Aboriginal communities record their knowledge and heritage about the rivers.

During the interviews, the elders were asked about changes they may have noticed in fish populations, erosion, riverbank vegetation, river flows and water quality.

Robert Burton, a Western Gugu Yalanji elder from the Mitchell River catchment, pointed out during his interview the changes in sediments he had seen in the river: ‘Look at the rocks around us; these are not from here’, he says.

‘Uncle Robert’s traditional knowledge has backed up TRaCK’s investigations which show the increase in erosion in this part of the river’, says Ruth Link, Chair of the Mitchell River Traditional Custodian Advisory Group (MRTCAG).

The process of organising and conducting the interviews was driven by local Indigenous groups in both the Fitzroy and Mitchell catchments, but each group carried out their respective project in their own way.

The Yiriman Project, a community-based youth diversionary program, ran the project in the Fitzroy. Six young local people conducted and filmed the interviews.

In the Mitchell, MRTCAG worked with a crew from ABC Television and a cameraman from one of the local Indigenous groups.

Young people gain skills and knowledge in the Fitzroy

The Yiriman Project was established ten years ago by Nyikina, Mangala, Karrajarri and Walmajarri elders to engage young people in activities such as ‘back-to-country’ trips with their older people. Through the TRaCK project, they aimed to give young local people opportunities to develop their skills in interviewing and filming.

‘Yiriman engages young adults connected through family in meaningful roles in research projects and other activities so they are acknowledged and valued’, explains Yiriman women’s coordinator Michelle Coles.

‘Through projects like this one with TRaCK they are learning and practising traditional knowledge. They learn new skills about workplace culture, using technology and multimedia, while being exposed to a broader understanding of science, environment, policy and economy.’

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Annette Kogolo is a Yiriman cultural advisor and a Walmajarri traditional owner. 'Our organisation brings old people together with their young men and women to educate them through the telling of stories and passing on of skills', she says. 'This way, culture is handed down to the next generation who will then pass it onto their children.

'With the river-change work, we visited places all over Fitzroy catchment. Young people got to spend time with their elders, who shared their knowledge of the river places, waterholes, plants, animals, fish, everything—showing them their country, talking about how to look after country.'

Michelle Coles says that when they asked senior people about their availability to talk about changes they had seen in the rivers and wetlands, there was a groundswell of interest. 'We received strong support for taking down these stories so that the knowledge can be held for the future generations. This was a really strong feeling expressed by the old people.'

Mitchell River elders feel empowered

In the Mitchell River catchment, young people also interacted with their elders on country while recording the stories of river change. Here, filming was carried out by an ABC Television crew who travelled 1600 kilometres to visit six sites in one week.

MRTCAG organised the interviews with 34 elders from the traditional custodian groups of Western Gugu Yalanji, Gugu Mini, Koko Mullarichee, Mbarbarrum, Wokomin and Kuku Djungan.

'Whole communities were involved in the filming and it was a huge logistical exercise', says TRaCK researcher Professor Owen Stanley from Charles Darwin University. 'The local Indigenous people were involved in the organising, interviewing, filming and processing the video.'

Ruth Link believes the project had many benefits: 'Traditional owners have not had a chance to record their history in this way before. It was a unique opportunity to tell their stories on country. The video recording of the traditional owners' knowledge means young people can have that knowledge for years to come.

'The project also showed us that TRaCK researchers want to understand the water values of traditional owners. We now feel that there's respect, peace and responsibility between us, which is essential to partnerships. We can now look at TRaCK research and traditional knowledge to work out the key priorities for the catchment and work together on this.'

MRTCAG was formed by the traditional custodians of the middle and upper reaches of the Mitchell River to review and manage scientific research carried out on their country. Ruth Link believes the river-change project was important for fostering relationships between Indigenous people and TRaCK researchers.

'Their knowledge has never been spoken about before. It empowered them because they know about their country and their river. It made people feel like what they know matters', she says. 'People were saying at the end: "We have never experienced this before... it connects our people, each other, our land".'

Indigenous knowledge valuable for research and river management

For TRaCK, this information is central to discussions about managing and restoring rivers and predicting the impacts of any future developments on the rivers.

'For researchers to gain an understanding of how fish stocks, weeds and water quality have changed is invaluable and provides opportunities to make sensible suggestions on how best to protect the health of the river', says TRaCK researcher Dr Paul Close from the University of Western Australia.

Traditional owner Graham Brady talks about the changes he has seen in the Mitchell River.

Photo: Tony Hill, ABC

Photo: Yiriman Project

Senior Bunuba traditional owner George Brooking talks about changes to the Fitzroy River.

Professor Stanley agrees: 'The elders know what has happened over time to the rivers. Their knowledge highlights where research should take place. A lot of our research has focused on the main channel of the Mitchell River, but we are finding out from elders that the real problems are in the higher reaches of the river where there has been more pollution, degradation of river banks and water extraction for domestic and agricultural purposes.'

Water trading in northern Australia

By Mary O'Callaghan

Dam wall, Lake Argyle, Western Australia
Photo: Michael Douglas

Buying and selling water is big business in Australia's southern states.

Trade in water entitlements in 2008–09 is estimated at $2.8 billion, up from $1.7 billion in 2007–08. The bulk of this trade occurs in New South Wales, followed by Victoria and then South Australia.

Water has been the focus of national reform in Australia, largely driven by the National Water Initiative (NWI). The NWI represents a commitment by all jurisdictions in Australia to, among other things, develop a water-trading framework. It is regarded as the most important reform of water resources in the nation's history.

Already the NWI reforms have contributed to a significant expansion in water trade in south-eastern Australia. The legal framework to trade water exists in northern jurisdictions, but is there support for water markets in the north? And what are the implications for the design of water markets in the region?

As part of a research project coordinated by the North Australian Indigenous Land and Sea Management Alliance (NAILSMA), TRaCK researcher Dr William Nikolakis travelled across the north to explore people's values and attitudes to water markets in northern Australia. He surveyed 120 people representing industry, government, Indigenous groups, recreational groups and non-government organisations —people with at least some knowledge of, or interest in, water planning and/or water management.

'While the research is a snapshot in time, it does offer insights into the awareness and acceptance of water markets in the region, and how people's attitudes and values might influence the design of water markets', says Dr Nikolakis.

Why values and attitudes matter

Previous research has shown that the performance of markets is dependent on the attitudes and behaviour of water users and community acceptance in general, and that the trading framework must reflect people's values if it is to be supported and effective.

'Values are a preferred state of existence, such as, for example, equity and freedom', explains Dr Nikolakis, 'and the conduct for achieving this state of existence, such as respect and responsibility. They are the standards by which we assess the behaviour of society and individuals.

'Attitudes have a variety of definitions but for this work we see them as people's evaluative responses to issues, ranging from favourable to unfavourable, or ambivalent.'

Understanding Indigenous values and attitudes towards water markets was an important part of this study. Thirty per cent of northern Australia's land is owned by Indigenous peoples.

There is support for water markets

Of the 120 people surveyed, half of all respondents felt that creating a water market would be useful or extremely useful for managing water in their region (see Figure 2).

Similarly, almost half (48%) of Indigenous respondents felt that a water market would be useful, indicating that there is increasingly an awareness of the economic potential of water among Indigenous people.

That almost one quarter of Indigenous respondents neither agreed nor disagreed that water markets would be useful may reflect their mixed feelings and concerns on equity and environmental protection issues, Dr Nikolakis suggests.

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Irrigation in the Ord River catchment, Western Australia

Photo: Ian Dixon

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Almost all (87%) Indigenous respondents agreed that they could foresee water being used to support enterprise development in their community, such as agriculture, horticulture and tourism-based enterprises.

The study also shows that there is strong support for the notion that the economic benefits of water trading will be significant for relevant Indigenous interests. Two thirds of Indigenous respondents thought that the economic benefits of trading would be significant for Indigenous people (compared to just over half of all respondents).

'This highlights the high level of importance Indigenous respondents attached to enterprise development', says Dr Nikolakis, 'viewing water as potentially one mechanism to support economic outcomes across the north'.

Respondents' views were tempered by some concerns that Indigenous people may be alienated from markets and that the ecological impacts from markets could be significant.

Social justice and equity are important to people

An important finding of the study is that social justice and equity are important to people. Under an equitable water regime, all parties are treated equally and fairly. Nearly half of all respondents felt that current water management was not equitable.

'Only a third of all respondents considered water management to be equitable', says Dr Nikolakis, 'compared to only about a quarter of Indigenous respondents. This highlights that the equity issue is felt most acutely by Indigenous Australians, reflecting previous research that highlights Indigenous concerns of being alienated from water reform and markets'.

Indigenous people must be meaningfully involved

The study shows strong support for recognising and including Indigenous people in water reform and in the creation of water markets. Respondents from government, Indigenous groups and recreational groups felt that consultation and water policy had failed to adequately address the needs and interests of Indigenous Australians.

When asked to describe the most important design feature for a water market, the most cited feature was that Indigenous people should have some role in water markets, ranging from involvement in management and governance to planning, as well as recognition of Indigenous peoples cultural and commercial rights.

This was echoed in people's key policy recommendation for a meaningful recognition and involvement of northern Australia's Indigenous peoples in the development of water markets.

'There is a lot of work to do to address Indigenous needs and interests in water policy and management', claims Dr Nikolakis.

'Three quarters of government, recreational users and Indigenous respondents thought that Indigenous people had not been adequately consulted by government in developing water-management policies in their region.

'Most of them also disagreed that Indigenous communities' interests are reflected in water-management policies. So, while Indigenous Australians have been recognised in the NWI, they have not been meaningfully involved in the reform agenda.'

Joe Ross, Chairman of the Indigenous Water Policy Group which is facilitated by NAILSMA, agrees. 'The northern Australia leadership should think innovatively about developing instruments, such as Aboriginal equity in water trading, that transition Aboriginal people off passive welfare into employment and economic development', he says. 'It is totally unacceptable that Aboriginal people in northern Australia continue to rely on the largesse of the states.'

Environmental caveats

Both Indigenous and non-Indigenous respondents had consistent views on the needs of the environment, with 73% of all respondents disagreeing (38% strongly disagreeing) that environmental flows should be tradeable.

Support was also overwhelming for the preservation of some catchments and aquifers with unique values. Of all respondents, 81% agreed (44% strongly agreed) that some catchments and aquifers should be preserved for their ecological and cultural values. Indigenous respondents were almost unanimous on this with 92% agreeing (70% strongly agreeing).

How useful do you think it would be to set up a water market in your region?

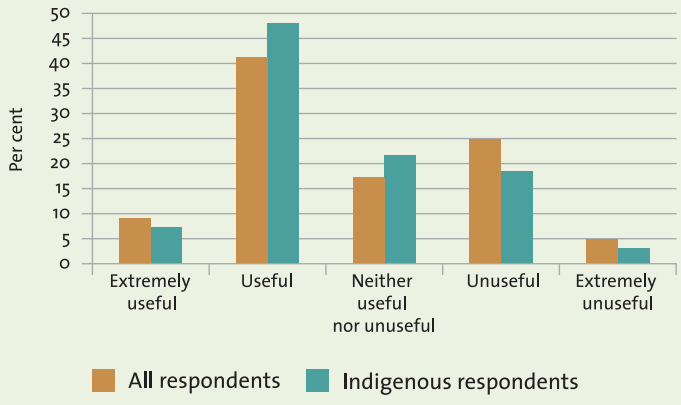


Figure 2: Almost half of all the people surveyed saw water markets in the north as being useful.

Design considerations for a water market

Overall, the findings offer insights for the design of water markets in the north.

'The first', says Dr Nikolakis, 'is that Indigenous involvement in water markets and reform is considered to be one way to address Indigenous disadvantage and to support Indigenous livelihoods. This involvement could range from water management and planning, to the recognition of customary and commercial rights.

'Second, there is support for more involvement from the general community in water management and planning. We need education programs to improve awareness of reform and we need more support for stakeholder input into reform, particularly where language barriers and cultural differences exist.

'Third, markets need to develop within a planning framework, with robust but simple trading rules to protect ecological and customary values.

'Fourth, some respondents emphasised that there should be minimal red tape and costs associated with markets, given the marginal operating conditions for producers across the north.'

Will Fargher is General Manager of the National Water Commission's Water Markets and Efficiency Group. He says that the findings underscore the importance of having good water-resource management in place—good water planning, good registration of entitlements, good measuring and good water accounting.

'Introducing water trading is not a costless exercise', he says, 'so it's good that people are thinking about the potential costs and benefits and what reforms might be required to respond to the demand for trade.'

Constraints to trading

Conditions in the north will influence both the design and scale of markets.

'Across the north there can be no trading outside of plan areas', says Dr Nikolakis. 'The conditions imposed on trading depend on the nature of the water resource. For groundwater there is generally no trading between aquifers. This may reduce the potential for trading across jurisdictions.'

In surface water systems where irrigation schemes exist there is generally only trading within schemes and, in the case of Western Australia, there can only be trades between cooperative members.

'The development of irrigation schemes is influenced by soil quality and water availability; suitable areas of land tend to be distributed sporadically across the north which means water trading, if it is to occur, will potentially only be available in discrete plan areas.'

Will buying and selling water become big business in the north? 'The development of water markets in the north will be contingent on water-based economic development and water scarcity in specific regions', says Dr Nikolakis. 'Our research has not yet concluded, but markets may be a useful tool in some instances to help meet the aims set out in a water plan.'

Will Fargher agrees. 'You don't pursue trade for the sake of trade', he says. 'You need demand for trade and the benefits from trade need to outweigh the institutional and administrative costs. Demand may not be there at the moment but it's good that we're considering the potential opportunities and benefits. There are a lot of benefits but there are also a lot of hurdles to cross in making sure we consider social, cultural and environmental perspectives and concerns.'

Irrigated agriculture in the Daly River catchment, Northern Territory

Photo: Ian Dixon

Photo: Ian Dixon

Katherine River, Northern Territory

Getting communities actively involved in water planning

By Mary O'Callaghan

Bore driller Henry van Tilburg and hydrogeologist Assoc. Prof. Malcolm Cox survey the Howard East area.

The Howard East area, located about 30 kilometres south-east of Darwin in the Northern Territory, is peppered with more than 3000 bores.

Mango and exotic-fruit growers, rural residents and the Power and Water Corporation rely on groundwater from the Howard East aquifer to satisfy horticultural, residential and commercial needs. The aquifer also supplements the main water supply from Darwin River Dam which services Darwin and Palmerston.

The Howard East area has recently seen rapid development in rural residential properties that were previously horticultural farms. Construction of 10,000 homes for the new city of Weddell to be built just south of Palmerston is planned to start within five years.

With no regional water plan in place to make sure that the water is managed sustainably for future generations, competition for water is slowly becoming a contentious issue. In a 'business as usual' scenario, it is likely that rural residents with older, shallow bores in the upper aquifer will run out of water earlier, in years of low rainfall.

The situation has prompted the Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS) to prioritise the aquifer for water-allocation planning.

The community recognises that a local water strategy needs to be developed.

'Everyone with a bore puts in initial investment to drill their own bore. And if they've got $15,000 sunk in their bore they want to know that the water supply is secure and the bore isn't going to run dry', says researcher Sharna Nolan from CSIRO who led TRaCK's on-ground investigations into planning in the Howard East area.

Building people's trust in the science

TRaCK researchers were keen to trial tools and techniques for getting communities actively involved in water planning. The important first step was to identify and understand the parties with a stake in the water supply.

The researchers began by interviewing 37 people including horticulturists, Indigenous representatives, fishers, local business people, local councillors and representatives of landcare groups.

'We wanted to identify the community's needs, issues and attitudes towards water planning', says fellow TRaCK researcher John Mackenzie from Griffith University, who also undertook case studies on collaboration planning in Cape York. 'And we wanted to help people overcome any barriers that might prevent them from engaging with the planning process.'

The team then shared the information from the interviews at community meetings and stakeholder meetings, where two problems rose above all others.

'First, there was limited understanding of groundwater systems at a regional scale, and of planning frameworks. Secondly, some people didn't have faith in the science that the government was using in making planning decisions and in managing the aquifer.'

It was clear to the researchers that before people could capably discuss the water issues, they needed to understand how the groundwater system worked and how their own bores worked within the broader system.

Underground water supplies are hard to visualise so researchers at Queensland University of Technology, led by Associate Professor Malcolm Cox, embarked on developing a 3D model of the Howard East aquifer system which people could look at to see the groundwater levels, the bores, and the relationships between rainfall, recharge and water levels.

The model aimed to answer people's questions such as:

- What is the geology of the area?
- How does the Howard East aquifer system work?
- How does the aquifer system respond to rainfall?
- How many bores are there and which aquifer do they draw from?
- Are older, shallower bores likely to run dry?
- What effect does the current rate of pumping have on local groundwater levels?
- Can we see the effects of pumping on the surface water bodies (e.g. Howard Springs, Girraween, McMinns Lagoon)?
- Is the aquifer taking longer to recharge during the wet season?

The model uses data from government records, and information from local councillors, Howard Springs residents, growers and stakeholder groups. The researchers also drew on the expertise of local bore drillers, government agency staff and other groundwater experts. The model shows cross-sections of the aquifer and includes short animations that illustrate the changes in water levels over time.

Participatory processes are important in water planning

The community was involved throughout the development of the model. The concept was launched at an initial community meeting, posters were displayed around rural Darwin, landowners with bores were surveyed, bore drillers helped with mapping the bores, and feedback was given by water agency staff and stakeholders. The model was showcased at a final community meeting.

'I think the model's greatest value is the visualisation', says Tim West of the Northern Territory Horticultural Association. 'A picture tells a thousand words. You can talk to people who have little concept of the system if you can show them or run them through a tool like this. It's a great tool for drillers or any horticulturist thinking of developing.'

The model also gave people a holistic view of the system, especially when they could see the impact of their own bore on the aquifer system.

'According to the feedback we received, the main strength of the tool is people's strong sense of ownership and acceptance of the final product', says John Mackenzie. 'The focus group said they were more likely to use it because they trusted the sources of information that it was based on, and because they had been involved in developing it.'

Kelly Howitt from NRETAS is the water planner for the Howard East aquifer. 'The TRaCK workshops dramatically raised awareness about water-allocation planning and why it is important for the Howard East region', she says. 'The stakeholder analysis also allowed us to understand the level of interest and the capacity of various groups and this has informed our communication strategy.'

NRETAS has adopted the approach of holding community forums before starting its water-allocation planning processes.

'The TRaCK workshops in Howard East happened well before we started the water planning process', says Kelly Howitt. 'So, when we went in, the community was anticipating we were coming and already had an awareness of the process. It showed us the value of holding forums to introduce people to water planning and what it's all about before we formally start the process.'

Lessons from this case study will help to inform a set of national guidelines and principles for water planning across Australia.

John Mackenzie says the feedback demonstrates why participatory processes, or collaboration, are important in water planning.

'The National Water Initiative says we need to expand the role of community in water planning, but the current role of planning agencies is best described as advisory as opposed to collaborative. While final decisions about water allocation are ultimately made by government, there is much greater scope for community input into the process. What we need is a collaborative approach, where people are actively working together.'

True collaboration in water planning can only happen, he says, when:

- the community is confident that the technical information used in planning is adequate and accurate
- tensions in the community have been resolved or are being managed
- appropriate forums exist for meaningful Indigenous participation
- the science is well communicated
- decision making is transparent, reducing the perceptions that outcomes are predetermined
- administrative flexibility has been designed into the planning process
- the planning needs of the agency match the expectations and needs of the community
- regional water planners are given the time to collaborate with the community
- community representatives, who will have different levels of knowledge and experience, are given the opportunity to build their capacity and learn from each other
- community representatives are given plenty of opportunities to deliberate and negotiate

Tailoring the approach to fit the context

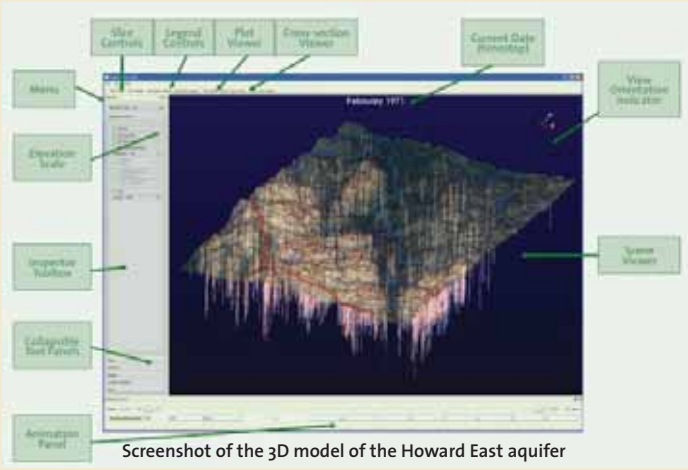
To help water planners in the north establish the right conditions for collaboration, the TRaCK team identified and tested a suite of tools and standards, many of which had been used for purposes other than water planning.

Customising them for northern Australia, they then embedded them within an adaptive management framework so that planners can select tools depending on what phase of the process they are in.

'No two water-planning processes are alike', says John Mackenzie. 'Catchments, the communities that live in them, the climate to which they are subject and the rivers themselves are different in many ways. Water managers should be mindful of this and adopt an approach to collaboration which reflects these differences.'

The framework and tools are published on the new Water Planning Portal at <http://waterplanning.org.au>.

'Implementing a collaborative engagement strategy for a water plan relies upon a fit-for-purpose approach', he adds. 'The Water Planning Portal is designed to help planners select planning tools to tailor their strategy to achieve this.'



Screenshot of the 3D model of the Howard East aquifer

The Howard East area

Fact sheets

The following fact sheets are available on the TRaCK website: www.track.gov.au

Scenario evaluation fact sheets
1: River futures in Australia's tropical north
2: Building better Indigenous participation
3: Collaborative water planning
4: Integrating knowledge to support adaptive management

Assets and values fact sheets
1: The economic value of rivers
2: Indigenous values and river flows

River and coastal settings fact sheets
1: People and the economy
2: Classifying river landscapes
3: Sorting Australian rivers by ecology and flow

Material budgets fact sheets
1: Sediment and waterholes
2: Sediment and nutrient loads
3: Nutrients in rivers
4: Water budgets
5: Water quality monitoring

Food webs and biodiversity fact sheets
1: River food webs
2: Waterhole food webs
3: Floodplain food webs
4: Healthy estuaries
5: Flows and ecological assets
6: Estuarine fish
7: Environmental flow tools
8: Diversity of river life
9: Northern Australia aquatic ecological assets

Sustainable enterprises fact sheets
1: Water markets
2: Indigenous rights in water
3: Sustainable economies: Arnhem Land case study

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About TRaCK

TRaCK was established in 2007 as a research hub under the Commonwealth Environment Research Facilities Program to provide the science and knowledge that governments, communities and industries need for the sustainable use and management of Australia's tropical rivers and estuaries.

The research consortium is led by Charles Darwin University, CSIRO, Griffith University, the North Australia Indigenous Land and Sea Management Alliance and the University of Western Australia.

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