Department of Planning and Environment

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NSW GOVERNMENT

Groundwater science research priorities

Research prospectus

March 2022

Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Cover image – Groundwater sampling. Credit: Madhwan Keshwan / DPE

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Groundwater science research priorities

The Groundwater Management and Science team of the NSW Department of Planning and Environment has identified research priorities to improve our understanding and the way we manage our state's groundwater resources.

The Water Group of the NSW Department of Planning and Environment (DPE) is responsible for planning, developing policy and establishing the regulatory frameworks for regional and metropolitan water in NSW. This document lays out the Water Group's groundwater science research priorities for improving our understanding and management of groundwater in NSW.

The priorities were set by the Groundwater Management and Science team which provides technical hydrogeological support across the DPE Water Group. This includes supporting developing and implementing policy, management plans, resource monitoring programs, the analysis and evaluation of data and information for resource assessment. The team provides technical advice to WaterNSW and the Natural Resources Access Regulator in their regulatory roles in the administration of licences, approval and compliance activities. The team also provides technical advice to the DPE Planning and Assessment Group in their assessment and management of state significant developments and infrastructures projects.

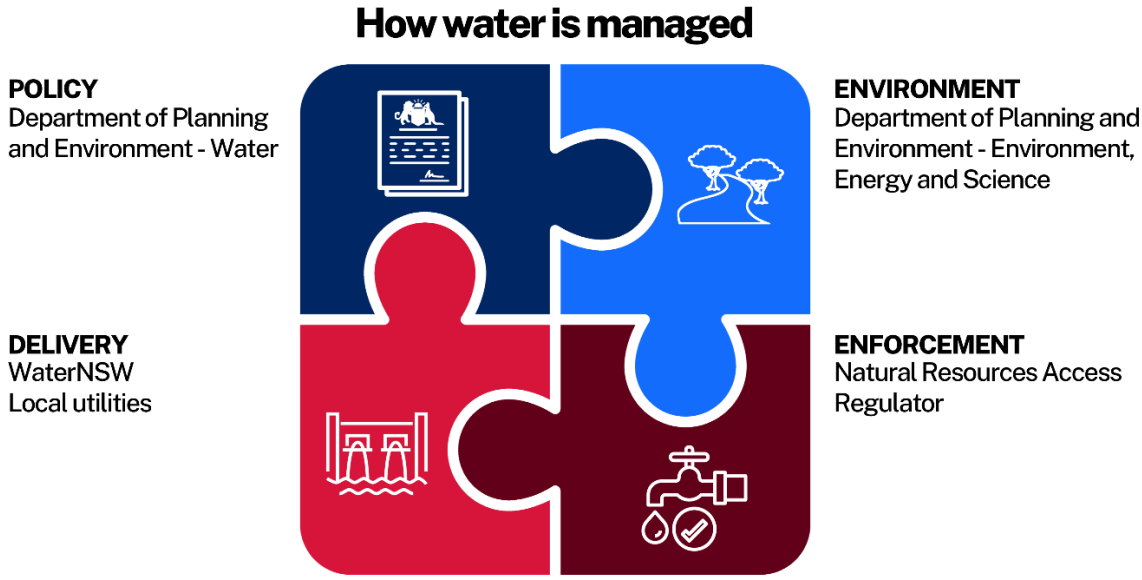

Figure 1 - roles of the major agencies involved in managing water in NSW

Why we need research into groundwater science?

Groundwater is an important water source for NSW, supplying 20-30% of all water needs. It is a key water source for many regional centres and communities, agriculture and mining, and is vital to the health of many diverse ecosystems.

Around 140 inland towns rely entirely on groundwater for town water supplies, and over another 100 towns are partially dependent on groundwater. Industry, in particular agriculture, is the largest user of groundwater across the state accounting for 90% of all licenced entitlement. In total there are around 12,400 access licences that authorise approximately 2,000 gigalitres of entitlement. This corresponds to over 14,500 production bores in 240 individual water sources.

As it is likely groundwater will become an increasingly important resource in the future, our policies and plans will need to adapt to changes to pumping demands and climate. To achieve this, we will need to:

- keep improving our understanding of groundwater processes through good science,
- have access to the right data and information and
- use the latest technologies to analyse and communicate potential effects on water at both the regional and local scales.

Our capacity to develop new technologies and undertake dedicated research is limited. The Groundwater Management and Science team is interested in collaborating with researchers and students to assist them in scoping, resourcing and delivering projects that can help us improve groundwater management in New South Wales. Our team can support individual projects with technical expertise and extensive knowledge of the New South Wales groundwater, guide researchers on available data held by New South Wales government agencies and facilitate access to government monitoring infrastructure that are owned and managed by WaterNSW.

The department's capacity to financially support specific research projects varies and depends on government funding programs from year to year. Funding is typically offered over a single financial year, with the amount available varying from year to year. In some cases research projects can be incorporated into large multi-year government projects, however this is unusual and non-routine, and these projects need long lead times.

The department is interested in supporting projects from PhD level research to more report style theses aligned to Honours or Masters level studies. These are likely to develop new knowledge, technology, or quantification methods. Undergraduate projects may also prove useful by focusing

on evaluating the present state of the resources in an area by describing or quantifying the processes that have led to the present day.

Research topics

We make decisions about how to manage groundwater based on how we predict the future is likely to be, and the vision we are trying to achieve. As a result:

> The type of science we primarily need is that which helps us answer the question “what would happen if…”.

The key aim of our research is to understand more about the underlying hydrogeological processes that affect our groundwater sources, and how the hydraulic, chemical or biological characteristics may change from implementing a future policy or management rule. Understanding these processes and how they vary over space and time will improve our ability to predict and quantify future changes resulting from extraction, changes in land use and climate.

The research topics presented in this document include potential projects that aim to **build our understanding of groundwater science**. There are also projects to **improve our methods of analysing and quantifying groundwater**, which are more related to how we use groundwater science to support decisions about how we manage groundwater.

As well as these science-based themes, we are interested in exploring what new technologies can bring to the **communication of groundwater science and making groundwater data available to the public**. While transferring scientific knowledge is not a research topic in itself, the department is keen to look for communications opportunities that may arise in project proposals. We are particularly interested in tools that enable groundwater information to be made publicly available.

Some context on how the department would benefit from new knowledge from each of the research topics is provided below. This is not a comprehensive list of potential projects and researchers are encouraged to approach the department on other groundwater related projects.

The department also considers the cultural, social and economic values of groundwater when making decisions that affect groundwater management. Whilst these aspects have not been included in this prospectus, the Groundwater Management and Science team can facilitate discussions and collaborate with appropriate internal teams if a proposed research project incorporates these aspects of groundwater management.

Recharge processes and methods of estimation

The department quantifies groundwater recharge and uses this to set groundwater extraction limits at the water source scale in New South Wales. As such, the department is interested in projects that will improve our capability to quantify recharge both at the broad water source scale and at the scale of the individual recharge processes.

Understanding these processes can improve estimates for groundwater modelling applications. Our overall aim is to have a suite of science-based recharge estimate methods, so we can select the appropriate techniques for any particular groundwater source given its characteristics and level of risks.

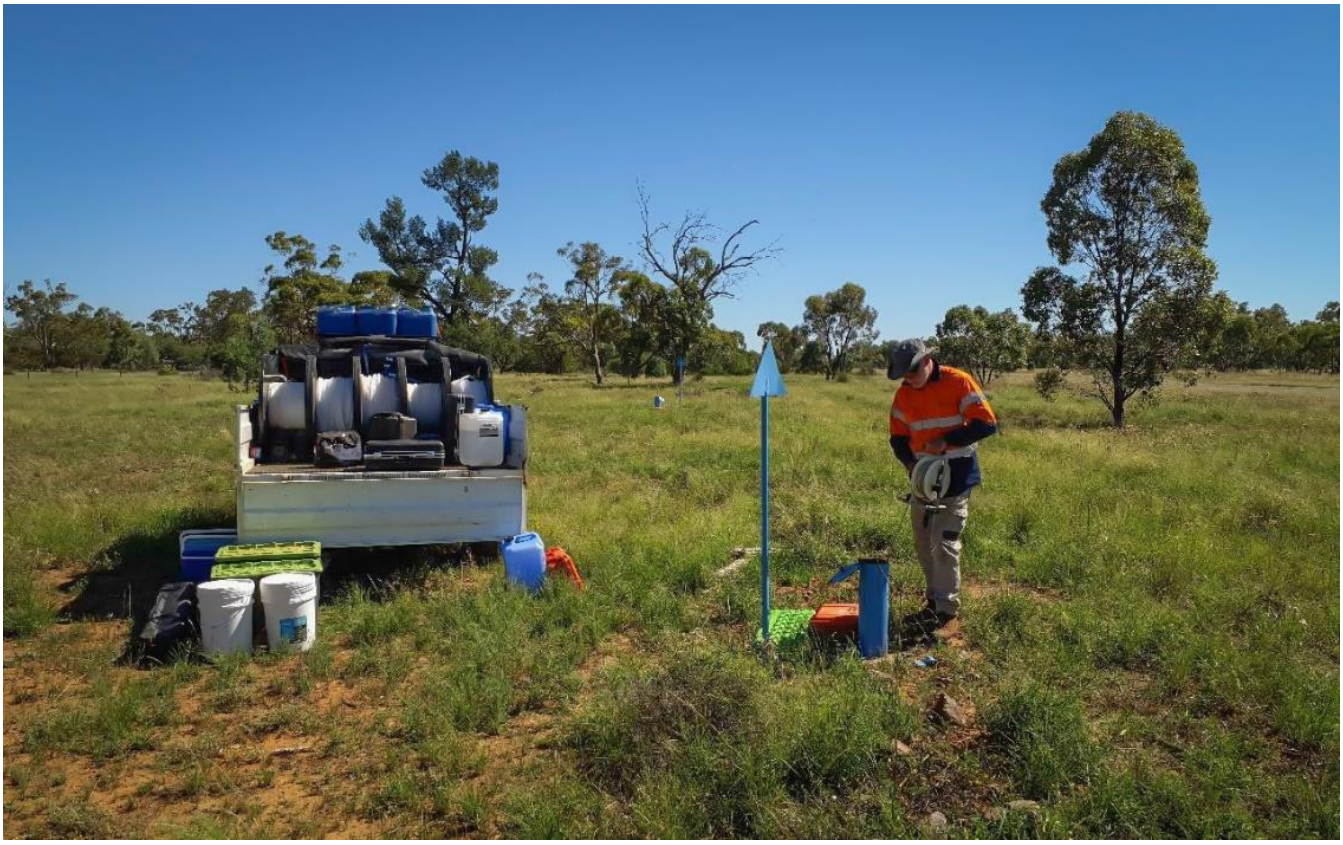

Figure 2 - Groundwater sampling, isotopic analysis can be used to inform recharge. Credit: Andrew Davidson / DPE

Examples of projects include the process focused research, such as the physical and chemical processes within the unsaturated zone; those that evaluate the variability of recharge across different geologies or within a large hydrogeological basin; or smaller area investigation such as quantifying recharge of a discrete groundwater system.

Understanding anthropogenic influence on groundwater recharge is also important to help develop broader water and landscape policies. For example, the department is interested in studies that investigate changes to recharge in the context of river regulation, land development on floodplains, urbanisation, and climate change.

Examples of projects include:

- estimating recharge for a particular groundwater source or area. Two specific areas of interest are the Sydney Basin and Bungendore Alluvium

- evaluating recharge estimate techniques for systems with different characteristics
- establishing the impacts of climate change either regionally or locally, particularly the impact on coastal groundwater systems
- assessing recharge on floodplains, and understanding the relationship of flooding and groundwater level changes

Surface water - groundwater connectivity

Across New South Wales there are a range of management and policy provisions to manage the connectivity of groundwater and surface water. The department is interested in supporting projects that help apply theoretical understanding of these interactions to a management framework.

As examples, research projects may explore:

- the magnitude and timing of groundwater pumping impacts on surface water and the spatial variability of these impacts at the river reach and water source scale
- techniques to characterise systems by the lag time and expected magnitude of groundwater pumping impacts to underpin common management responses
- quantifying surface water - groundwater exchanges
- methods to upscale local studies of a river reach to inform management at a groundwater source scale
- identifying target indicators to describe the exchange between surface water and groundwater
- the use of remote sensing to map areas of groundwater discharge to streams in upland catchments,
- use of remote sensing to map and monitor near surface groundwater and seepage from large water supply storages on floodplains or in the vicinity of in-river structures, particularly along the Murray and Murrumbidgee rivers
- the use of groundwater chemistry and age tracers to map and quantify the interaction.

Groundwater chemistry

Research is needed into the geochemical effects of mixing water induced from long-term hydraulic changes in a groundwater system.

This includes research into:

- the chemical processes associated with induced mixing of groundwater within pumped groundwater systems,
- the use of geochemical modelling to improve understanding of the geochemical processes and rates of water quality changes, and

- the use of predictive models/methods, such as coupling chemical and flow modelling, to predict induced changes and whether this change is irreversible, under a range of pumping scenarios.

This research could potentially make use of existing datasets. For example, in 2021 the NSW government collected 957 samples from 588 sites as part of a statewide baseline sampling program.

The suite of analytes included major ions, metals and stable isotope data. Smaller sampling programs also took place between 2018 and 2020.

> This data, and historical groundwater chemistry data, is now publicly available and can be used by researchers to support their projects.

Figure 3 - Groundwater chemistry. Credit: Andrew Davidson / DPE

Research or investigations could utilise this dataset, as well as datasets from other state and local government agencies, to:

- characterise the chemistry of a groundwater source or larger hydrogeological basin
- identify potential suitability issues for town water supplies in particular geologies, for example the presence of arsenic, selenium and uranium
- improve our understanding of groundwater flow paths from mapping of groundwater age

We are also interested in the potential to use water quality data to improve the calibration of groundwater flow models. A project could investigate the optimum parameters / analytes for a monitoring program intended to provide the groundwater and surface water quality data to improve calibration of one of the department's regional groundwater models.

Modelling could also be used to evaluate appropriate buffer distances around contaminated sites. This information could then be incorporated into plan offset distances. A study may consider a range of aquifer types and hydraulic and chemical characteristics to inform this.

Groundwater dependent ecosystems

Currently, it is difficult to develop robust rules to manage effects on groundwater dependent ecosystems (GDEs) due to limited information about how much water each ecosystem requires to maintain its health. The department is interested in projects that investigate:

- biological or biogeochemical indicators of groundwater dependency and ecosystem health,
- techniques to map these at a groundwater source scale,

- methods to identify the source aquifer for specific GDEs such as springs, that is, GDEs that rely on groundwater discharge,
- the use of remote sensing for GDE monitoring, and the
- distribution of stygofauna species and their environmental significance / function.

Figure 4 - Old Gerara groundwater springs. Credit: Faye Williamson/DPE

Specific locality studies could consider projects that use remote sensing techniques to map groundwater springs and its potential for ongoing monitoring of spring discharge. Establishing the inherent strengths and limitations of different techniques across a range of landscapes would help the department develop mapping and monitoring programs.

Groundwater impact assessments

The assessment of proposed developments is a significant role for the Groundwater Science and Management team. These proposals range from very small scale, in the form of applications for approval of relatively low yielding water supply bores, to very large mining or infrastructure projects that have gone through an extensive environmental assessment process.

We are interested in working with researchers to fill knowledge gaps and to use the latest technologies to both improve our technical approaches to evaluating these assessments. We are also interested in techniques and methods that would reduce the staff resources required for this work.

Local scale production bore assessments

The department has built and maintains numerous regional groundwater flow models that are used to assess water budget inputs / outputs to determine the effect on the groundwater pumping regimes over the long term. These models may cover several groundwater sources within the model domain and are used to inform decisions on a groundwater source scale, that is 10s - 100s km^2. The department also uses analytical models to assess applications for new production bores or to trade entitlement or allocations. These assessments are at the scale of 1 - 10s km^2.

The Groundwater Management & Science team is interested in software and/or technology development that would lead to a modelling interface to interrogate, refine and run a portion of a regional groundwater model suitable for small scale impact assessments.

The objective is to have a technically robust tool that can be used by hydrogeologists rather than specialist groundwater modellers. The final product is likely to require development over multiple stages. To be of use, the tool must:

- use automations
- reduce staff time on assessment activities
- be applicable to the scale of the assessments.

Project impact assessments

Large scale developments have the potential to have significant and irreversible impacts on groundwater. As well as the development in the science in understanding and quantifying these impacts, we need to consider what advances in technology and software would allow effects on groundwater to be reported publicly. The community is particularly concerned about the cumulative impacts of mining. Developing reporting tools where information can be displayed online and publicly used would help clarify the expected cumulative impacts of projects.

The department is interested in research would help further the science underpinning the impact assessment of large mining and transport infrastructure projects such as tunnels. Projects could investigate:

- refining how we can model groundwater inflow from induced structural changes to geology from mining
- improving land subsidence predictions and associated impact to near surface groundwater systems
- use of mine subsidence engineering model outputs as inputs to groundwater numerical models
- understand how infrastructure developments, either large or cumulative, affect groundwater processes and urban liveability
- improving long term predictions of aquifer depletion and re-equilibrium, for example the uncertainty of the final void predictions

Groundwater monitoring and reporting

Research in new monitoring technologies and data analysis technologies, at all scales, can identify where government should invest in future monitoring programs. This could lead to addressing data gaps in areas with limited data without the need for expensive monitoring bore infrastructure.

Figure 5 - Groundwater monitor bore drilling. Credit: Jake Turi / EMM

As well as investigating new technologies, projects that evaluate existing methods and the environments in which they can appropriately be used would assist in developing minimum standards, particularly for proponents of developments. For example, evaluations of the reliability of use of vibrating wire piezometers, in-situ water quality samplers, down-hole EC loggers, and down-hole tools to determine aquifer parameters would help develop minimum standards.

The department has access to data on a range of groundwater attributes collected, analysed and reported by proponents. This data is typically already public however is not easily assembled as it is spread across a wide range of reports. Collating this data into an online database would produce a valuable resource to industry, government and researchers alike.

The next step from this would be to develop tools to map and report these parameters in three dimensions. The Groundwater Management and Science team has done some preliminary work on compiling some of the hydraulic parameters data and we are interested in collaborating with researchers on developing this potential resource further.

Contact us with your research ideas

While the above is a snapshot of our current priorities, research ideas to advance our knowledge and understanding in groundwater management may extend beyond what is indicated in this document.

To discuss your ideas with us please contact Sue Hamilton, Principal Hydrogeologist at Sue.Hamilton@dpie.nsw.gov.au and Fabienne d'Hautefeuille, Manager Groundwater Management and Science at Fabienne.d'Hautefeuille@dpie.nsw.gov.au .