Please note: the substantive content of the 2026 NRI Roadmap Survey begins at Question 20 (with prior questions dealing with administrative and other information).

As such all submissions that are published include the responses submitted from Question 20 onwards only.

Q20.

Part 2: Research themes

2.1 NRI comprises the assets, facilities and associated expertise to support leading-edge research and innovation in Australia and is accessible to publicly and privately funded users across Australia and internationally. We are seeking your input on possible directions for future national-level investment - i.e., where the requirements are of such scale and importance that national-level collaboration and coordination are essential.

The 2021 Roadmap used a challenge framework to support NRI planning and investment. With this in mind, consider likely future research trends in the next 5 - 10 years, and with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale and
- describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities.

Q21.

Resources Technology and Critical Minerals Processing

Q22.

Food and Beverage

Q23.
Medical Products

Q24.
Defence

Q25.
Recycling and Clean Energy

Q26.
Space

Q27.
Environment and Climate

Water sustains life and environment; it underpins our society and enables industry. Access to secure and sustainable source of water is critical to the wellbeing of Australians. Without water our towns and cities would be unliveable. In Australia, being the driest inhabited continent, groundwater is critical and accounts for over 30 per cent of our total water consumption. For large parts of Australia groundwater is the only reliable, cost-effective water source. It sustains many environmentally significant groundwater dependent ecosystems, rivers, and coastal systems. Research, modelling, and the data sets used to inform planning and management decisions must be based on the best available science. The new National Water Agreement (NWA) outlines seven national objectives that will guide water management and policy. Objective four asks that "Water planning and management decisions are evidence-based, using the best available science, data and research." The new National Research Infrastructure Roadmap must ensure that groundwater infrastructure is elevated to national significance and supports the NWA. One of the most effective hydrogeological tools ever developed is groundwater age-dating using isotope techniques. They can deliver insight into recharge rates, mixing in groundwater systems, quantify the sustainability of groundwater resources, and provide critical data for understanding the transport of groundwater contaminants. Among the available isotope techniques, the long-lived radioactive noble gases 85Kr, 39Ar, and 81Kr are emerging as three of the best groundwater age tracers because they are chemically inert making them more reliable and they can be used to estimate water age over large timescales: from modern water (85Kr), water of several hundred years (39Ar), to really old water of several hundred thousand years (81Kr). These isotopes are measured using the newly developed quantum technology Atom Trap Trace Analysis and currently samples are sent to a limited number of overseas analysis labs. A new facility for Atom Trap Trace Analysis at the University of Adelaide aims to provide a sovereign capability and is already beginning to service the local user community. New and critical groundwater infrastructure, supporting emerging research, include: 1. New and emerging isotope infrastructure such as radiokrypton and radioargon isotopes. These isotopes are measured with the emerging quantum technology Atom Trap Trace Analysis (University of Adelaide). 2. Existing isotope infrastructure that is at insufficient scale such as radiocarbon, radiochlorine, tritium and stable noble gases (e.g. 4He). These isotopes can be measured at existing Accelerated Mass Spectrometry facilities (ANSTO and HIA) and stable noble gas mass spectrometry (CSIRO). 3. Data repository infrastructure for hydrological isotopes that are publicly available and accessible under the FAIR data principles (Findable, Accessible, Interoperable, and Reusable).

Q28.

Frontier Technologies and Modern Manufacturing

Q29.

2.2 The 2024 statement of National Science and Research Priorities (NSRPs) includes outcomes linked to each priority to assist in identifying critical research needed in the next 5 to 10 years.
Consider the priority statements and, with respect to one or more of the 5 priority areas as listed below:

- describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or
- not at sufficient scale and describe current national infrastructure requirements that you anticipate will no longer fit the definition of NRI in 5-10 years.

Do not limit your commentary to NCRIS funded capabilities, and where relevant, refer to the underpinning outcomes and research identified in the NSRPs document.

Q30.

Transitioning to a net zero future

A better understanding of groundwater recharge rates and connectivity is crucial for Australia to achieve its net-zero emissions goals. Understanding recharge patterns helps ensure sustainable extraction rates, reducing the need for energy-intensive water sources like desalination or large-scale water transport. Importantly, having effective, reliable, and trusted tools for mapping groundwater can accelerate groundwater management decisions, providing investment confidence. A key objective of the Groundwater Strategic Framework 2016-2026. Among the most valuable hydrogeological techniques is groundwater age-dating using isotope methods. These techniques offer valuable insights into recharge rates, groundwater mixing, sustainability, and the movement of contaminants within groundwater systems. Isotopes are essential in developing a national strategy for sustainable groundwater management. The CSIRO and The University of Adelaide, with the support of AuScope, have built a globally unique facility that can measure the amount of stable noble gases (He, Ne, Ar, Kr, Xe), radioactive noble gas isotopes (85Kr, 81Kr, 39Ar), and tritium (3H) at ultra-low levels in water. • The long-lived radioactive noble gases 85Kr, 39Ar, and 81Kr are emerging as three of the best groundwater age tracers because they are chemically inert making them more reliable and they can be used to estimate water age over large timescales: from modern water (less than 50 years; 85Kr), water of several hundred years (39Ar) to really old water of several hundred thousand years (81Kr). These isotopes are measured using the newly developed quantum technology Atom Trap Trace Analysis at the University of Adelaide. • Stable noble gas isotopes and tritium via in-growth are measured at CSIRO's Environmental Tracer Lab via stable noble gas mass spectrometry. Noble gas isotopes stand out as amongst the most reliable due to their chemical inertness, well constrained source and sink mechanisms, and uniform global distribution. Helium-4 is the most reliable indicator of old groundwater. New critical research infrastructure that supports the measurement of radioactive noble gases at the University of Adelaide Atom Trap Trace Analysis facility and stable noble gases at CSIRO are needed to deliver a net-zero future. This research infrastructure will be supporting risk based, consistent and efficient regulation of groundwater resources. It will provide cutting edge data required for effective groundwater management, supporting both environmental sustainability and economic development, and play a key role in Australia's transition to a net-zero future.

Q31.

Supporting healthy and thriving communities

Q32.

Elevating Aboriginal and Torres Strait Islanders knowledge systems

Q33.

Protecting and restoring Australia’s environment

A deeper understanding of groundwater recharge rates and connectivity is essential for protecting and restoring Australia’s environment. By gaining clearer insights into how aquifers recharge and how different water systems are interconnected, Australia can manage its groundwater resources more effectively, protecting groundwater dependent ecosystems. Sustainable groundwater use helps maintain natural habitats, wetlands, and river systems that rely on steady water flow, while preventing over-extraction that could lead to land degradation and loss of biodiversity. Among the most valuable hydrogeological techniques is groundwater age-dating using isotope methods. These techniques offer valuable insights into recharge rates, groundwater mixing, sustainability, and the movement of contaminants within groundwater systems. Isotopes are essential in developing a national strategy for sustainable groundwater management. The CSIRO and The University of Adelaide, with the support of AuScope, have built a globally unique facility that can measure the amount of stable noble gases (He, Ne, Ar, Kr, Xe), radioactive noble gas isotopes (85Kr, 81Kr, 39Ar), and tritium (3H) at ultra-low levels in water. • The long-lived radioactive noble gases 85Kr, 39Ar, and 81Kr are emerging as three of the best groundwater age tracers because they are chemically inert making them more reliable and they can be used to estimate water age over large timescales: from modern water (less than 50 years; 85Kr), water of several hundred years (39Ar) to really old water of several hundred thousand years (81Kr). These isotopes are measured using the newly developed quantum technology Atom Trap Trace Analysis at the University of Adelaide. • Stable noble gas isotopes and tritium via in-growth are measured at CSIRO’s Environmental Tracer Lab via stable noble gas mass spectrometry. Noble gas isotopes stand out as amongst the most reliable due to their chemical inertness, well constrained source and sink mechanisms, and uniform global distribution. Helium-4 is the most reliable indicator of old groundwater. Investment in new radioactive noble gas isotope techniques, measured with Atom Trap Trace analysis at the University of Adelaide, and stable noble gases, measured at the CSIRO, will provide researchers in government and academia the tools required to better understand and manage groundwater. It will aid in identifying and protecting groundwater recharge areas. This will in turn support efforts to restore damaged aquifers improving the resilience of Australia’s environment and enabling ecosystems to thrive even in the face of climate change. Proper management of groundwater resources not only safeguards water quality but also plays a critical role in environmental conservation efforts, ensuring a healthy and sustainable future for Australia's natural landscapes.

Q34.

Building a secure and resilient nation

Q35.

2.3 The case for a new NRI capability, or enhancements to existing capabilities, typically emerges through advocacy from research communities clustering around rigorously identified needs and goals. Such a concept could respond to a requirement for novel or expanded capacity within a domain, or across domains, and must be such that it could only be made available with national-level investment.

If you have identified such a requirement, briefly describe the need, the proposed infrastructure capability, the medium-term goals, impacted research communities, and the timeframe over which you advocate its establishment. Your response can include links to relevant existing reports.

The Need: Determining the age of Australia's groundwater is crucial for developing a national sustainable groundwater management plan. Groundwater hydrologists rely on using chemical tracers to infer the age and movement of water in aquifers and their rate of replenishment. The measurement of these tracers is a critical input into the development of groundwater models that are relied upon by government and industry to support decisions on the sustainable use of groundwater. Existing, age tracers such as 14C and 36Cl are important tools. However, because they are chemically active, they are often affected by complex chemical interactions or unknown input parameters. The properties of the noble tracers make them ideal for groundwater investigations. They are chemically inert and have relatively simple transport processes, making them the most reliable and effective method for age-dating of groundwater. They more reliably predict the aquifer age and movement of water and replenishment rate when compared to conventional tracers. They can be used to compliment and add value to other tracers like 14C and 36Cl by providing calibration, improving their reliability. If Australia wants to develop trusted models of groundwater to support solutions to National Challenges including transitioning to a net zero future and protecting and restoring its environment, Australia needs access to a world class noble gas facility. It will support the Groundwater Strategic Framework 2016-2026 and the new National Water Agreement. The Infrastructure Capability: The CSIRO and The University of Adelaide, with the support of AuScope, have built a globally unique facility that can measure the amount of stable noble gases (He, Ne, Ar, Kr, Xe), radioactive noble gas isotopes (85Kr, 81Kr, 39Ar), and tritium (3H) at ultra-low levels in water. • The long-lived radioactive noble gases 85Kr, 39Ar, and 81Kr are emerging as three of the best groundwater age tracers because they are chemically inert making them more reliable and they can be used to estimate water age over large timescales: from modern water (less than 50 years; 85Kr), water of several hundred years (39Ar) to really old water of several hundred thousand years (81Kr). These isotopes are measured using the newly developed quantum technology Atom Trap Trace Analysis at the University of Adelaide. • Stable noble gas isotopes and tritium via in-growth are measured at CSIRO's Environmental Tracer Lab via stable noble gas mass spectrometry. Noble gas isotopes stand out as amongst the most reliable due to their chemical inertness, well constrained source and sink mechanisms, and uniform global distribution. Helium-4 is the most reliable indicator of old groundwater. There is limited capacity globally for measuring this combination of noble gases. The combined stable and radioactive noble gas and tritium facility based on noble gas mass spectrometry is entirely unique in the world. There is also concern about using some foreign facilities for geopolitical reasons. As radioactive noble gas tracers become more widely used globally, sending radioactive tracers overseas for analysis takes up to a year to be processed: this is a clear barrier to uptake by industry. Medium Term Goals: Building on the $10M invested in these facilities to date, we propose the establishment of a National Noble Gas Facility for Groundwater (NNGFG) linked to AuScope under NCRIS to accelerate the delivery of real-world groundwater solutions, support groundwater research and enable the sustainable growth of the minerals, energy, and food industries in Australia. The NNGFG will be a national collaboration hub for groundwater research that will strengthen AuScope and NCRIS research initiatives including: Coastal Research Infrastructure; AuScope's Downward Looking Telescope; Earth Composition and Evolution; Environment & Climate; and Simulation, Analysis and Modelling activities. NNGFG will also leverage and add value to Auscope's AusGeochem database. The NNGFG will provide services at competitive prices and turn-around times delivering better groundwater outcomes for Australia. The information will enhance our research efforts, increase industry confidence in potential mineral exploration areas or food production regions relying on groundwater for irrigation. Together with Auscope, the Heavy Ion Accelerator Facility, ANU, and ANSTO, we will explore the development a cross-NCRIS collaboration to support a national groundwater isotope capability including the stable and radioactive noble gases, tritium, carbon-14, and chlorine-36. Impacted Research Communities: The user community will include organisations in government responsible for groundwater management; academics whose research involves the understanding of groundwater systems, contaminant transport, groundwater flow and recharge; and industry such as the energy and agriculture sectors that are users of groundwater. Over the past year our team has conducted over 19 presentations to end-users across government academia and received 13 letters of support. The proposed facility is aligned with the United Nations Sustainable Development Goals: Clean Water and Sanitation for All (Goal 6) through sustainable management of groundwater, while the management of our groundwater resources is crucial for building Resilient Infrastructure and Industrial Development (Goal 9), Sustainable Cities and Communities (Goal 11) and ensuring Sustainable Consumption and Production Patterns (Goal 12). Timeframe: Currently, the stable noble gas facility at the CSIRO Adelaide Waite Campus is operational and providing measurement of hundreds of samples per year. The Atom Trap Trace Analysis facility at the University of Adelaide is measuring radiokrypton and is currently being upgraded to measure hundreds of krypton samples per year by mid-2026 and argon-39 by 2028. A third facility, the CSIRO TRItium Facility by Ingrowth (TRIFIN), will become operational by 2026.

Q36.

Part 3: Industry perspectives

This section is seeking input specifically from industry-based respondents. Other respondents can skip this section.

Recommendation 6 of the [2021 Roadmap] related to improvements in industry engagement with NRI. To complement work on this topic that has occurred since then, we are seeking additional advice on NRI requirements as perceived by current or potential industry-based users.

Q37.

3.1 Have you (or your organisation) interreacted with or used Australia's NRI?

- ○ Yes
- ◉ No

Q38.

3.2 If so, please briefly outline the NRI capabilities you (or your organisation) have interacted with or used. Do not limit your response to NCRIS capabilities.

This question was not displayed to the respondent.

Q39.
3.3 Please indicate your (one or more) primary reasons for interacting with NRI:

This question was not displayed to the respondent.

Q40.
3.4 If you answered no, please indicate your (one or more) primary reasons:

- ☐ I did not know about it
- ☐ Other facilities suit my needs better
- ☐ I would like to, but cannot get access due to geographical location
- ☐ I would like to, but believed that access was only available to academic researchers
- ☐ I am not aware of any capability that meets my needs
- ☐ Other (please specify)

Q41.
Part 4: Other comments
4.1 Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

Q49.
4.2 Optional Document Attachment.
Note: Our strong preference is that answers are provided against the relevant questions in the survey. However, this file upload option is available for submissions in file format, where needed. Please ensure the document includes your name or organisation.