Submission

2016 National Research Infrastructure Roadmap Capability Issues Paper

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Executive summary:

Our top level points are:

1. We welcome the opportunity to comment and provide strong support for **close engagement** of the environment and natural resource management capability **with environment and land management agencies** in the jurisdictions.

2. We outline **NSW priorities for environmental data and science** and link them to ongoing support for current National Collaborative Research Infrastructure Strategy (NCRIS) capabilities and to possible future NCRIS infrastructure development.

3. We support the idea of an overarching national **strategic plan for future environmental research capabilities, including infrastructure**. We note that technology is evolving rapidly in this field, and hence a strategic plan which identifies the top environmental data and research gaps that would provide national scale benefit could be a precursor to a strategic environmental research infrastructure plan.

4. It is timely to consider **a framework that integrates the most important data and science needs of the environment agencies** across Australia. We believe this could be developed in an appropriate time scale to inform a national strategic plan for environmental research capabilities.

5. We note there is an **opportunity to take a broader view** of NCRIS capabilities and integrate capabilities into a national framework that may not be directly funded by NCRIS.

1) Close engagement of state and territory land managers and environmental agencies

State and territory environment agencies all rely heavily on data collection from a very wide variety of sources on the full gamut of environmental issues for policy and program decision making. For example NSW is currently reforming its legislative and policy approach to land management and conservation (https://www.landmanagement.nsw.gov.au/). The new legislation will rely heavily on statewide datasets on, inter alia: species occurrence and distribution; soils; vegetation extent and condition; vegetation structure; remote sensing; land use history; and climate. Extensive ecological theory and models using these data will underpin scientifically based maps and tools. Two examples are: a statewide biodiversity conservation investment strategy to guide allocation of $240 m to private land conservation; a scientifically robust biodiversity assessment method to deliver a transparent and consistent approach to avoid, minimise or offset biodiversity impacts from development. Without extensive, current and sophisticated data and models, the NSW government will be hampered in its ability to implement its policies to support ecologically sustainable development.

NSW OEH can benefit strongly from the NCRIS Environment and Natural Resource Management infrastructure capability and would advocate for strong and direct engagement of relevant agencies in the jurisdictions.

2. NSW priorities for environmental data and science

The range of environmental data sets used for environmental policy and land management in NSW includes water (hydrology and quality); air quality; climate; soils; carbon; vegetation extent, condition and composition; geology; biodiversity; pests and weeds. Sources of data include: collection by agency scientists; provision of data from university and research agency collaborators; access from NCRIS facilities; acquisition from third party providers (in particular aerial and satellite digital imagery); provision by industry; provision by the community.

We provide a table (Table 1) that outlines NSW OEH major data needs, specific gaps, current and future possible linkages with NCRIS.

Particular areas of focus for NSW OEH that would be of national relevance include:

- A national coastal observatory to model and predict coastal responses affecting risk exposure at a regional to local scale (see case study 1 below)
- Infrastructure to support measurement, modelling and prediction for a national system of essential environmental variables
- An integrated approach to data management
- Better integration of infrastructure such as NSW BioNet/ALA/AEKOS that supports national observation, modelling and prediction of fauna and flora distribution, occurrence and future trajectories

3. An overarching national strategic plan for future environmental research capabilities, including infrastructure

The consultation plan refers to the possible development of an overarching national strategic plan for future environmental research capabilities. NSW OEH sees this as the single biggest opportunity offered by the NCRIS 2016 roadmap. We suggest that a national environmental research infrastructure and capability plan should have, as a major foundation, a clear understanding of the environmental data and science needs of the jurisdictions (see section 4). This would be in addition to building on existing plans such as the *National Marine Science Plan* and *Foundations for the future – a long term plan for Australian ecosystem science*.

Without such a national strategic plan, NSW will continue to support, publish to and access data from NCRIS facilities where these support state interests, but is less likely to grow its use of and contribution to NCRIS generated data. NSW OEH current involvement with NCRIS facilities is:

- IMOS: NSW OEH is engaged both as a partner and end user. An OEH staff member is a current NSW node deputy leader, and we lead the monitoring of the Port Hacking national reference station. We are involved in field deployment of the AUV facility, and the gliders, and data have been incorporated into long term monitoring programs run by NSW government. A major initiative of the NSW Marine Estate Management Authority (MEMA – see http://www.marine.nsw.gov.au/) is to develop a monitoring, evaluation and reporting program to support management of the NSW marine estate and we anticipate this will make good use of IMOS data.

- ACCESS: We rely on ACCESS to provide underlying meteorology forecasts for our daily air quality forecasts and for specific forecasts during air quality emergency incidents. We are considering use of ACCESS as a GCM within our next iteration of the NARCliM (NSW and ACT Regional Climate Model) regional climate modelling project (http://climatechange.environment.nsw.gov.au/).

- ALA: NSW BioNet (http://www.bionet.nsw.gov.au/) is one of the largest national contributors of data to the ALA. OEH are actively working with the ALA to implement new exchange mechanisms and remove governance barriers to enable better integration and use of data in ALA and NSW BioNet. Current focus is to implement real-time sharing of data from BioNet to ALA using OData web services.

- BioNet's primary objective is to aggregate data from all available sources including ALA to achieve the most complete and scientifically robust long-term repository of biodiversity data used for decision making in NSW. With ALA being the landing point for the majority of citizen science observations in Australia, the NSW BioNet roadmap has identified the need for better ways to use this increasingly important source of biodiversity data.

- TERN: NSW has some engagement with TERN, including using it as a publishing platform for some of our remote sensing information products. OEH also make some use of data originating from TERN, particularly from the longer term ecological research network.

Local infrastructure is still the primary source of data for NSW to support the particular requirements of the various environmental regulatory instruments (see Table attached).

4. An **interjurisdictional framework highlighting priority environmental data and science needs**

There are increasing efforts to create common platforms, national data standards and share infrastructure and data between the jurisdictions. For example:

- an interjurisdictional task force is creating a new common standard for flora survey data similar to DARWIN Core to facilitate the discovery, retrieval, and integration of information gathered through systematic surveys;
- NSW, WA, Queensland, CSIRO, and Geoscience Australia are in advanced stages of implementing a consortium to deliver a national data hub for satellite imagery and data sharing (see case study 2).

However each of these initiatives has a single capability focus. There is currently no overarching national strategy for:

- harmonising, integrating and quality assuring the environmental data
- storage requirements, and
- research and analysis needs of Australian state and territory jurisdictions

This challenge is of at least equal importance to the challenge of generating new data.

OEH suggests that a strategic environmental data and science framework that integrates the common elements required to fulfil the high level needs of the public land managers and environmental agencies in the jurisdictions would add great value both to individual jurisdictions and to the Commonwealth environment department which is charged with making decisions on a national scale.

OEH believes that such a framework could be developed in an appropriate time frame to support and inform a broader NCRIS process, and that it would be an important foundation piece for a national environmental research capabilities and infrastructure strategy.

5. Opportunity for broad synergies in collaborative research infrastructure capabilities

The jurisdictions have existing mechanisms for sourcing data and collaborating to improve data analysis and model development. It may be possible, where appropriate, to integrate jurisdictional data and infrastructure for sourcing data into a national collaborative research infrastructure framework. This would further emphasise that NCRIS is a national infrastructure system that adds value to the entire Australian economy, not a program of research infrastructure provided by the Commonwealth government alone. Examples of data and infrastructure that NSW OEH uses that might be suitable for consideration include remote sensing data; high resolution regional climate modelling data; air monitoring networks; NSW soils archive.

Access to state based infrastructure could be considered as a co-investment where interests and governance can be aligned. Cooperative models can also be developed. A precedent exists in the national primary industries research, development and extension framework (http://www.npirdef.org/). A current example is the Australian Copernicus Regional Data Hub described in case study 2.

Question 1: *Are there other capability areas that should be considered?*

The broad capability headings appear appropriate.

Question 2: *Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.*

We agree that leadership to determine priorities for research infrastructure is very important. We also agree that governance over data to achieve much greater integration and accessibility is an absolute priority.

The governance model should be driven by the vision of a particular NCRIS infrastructure capability. OEH recommends participation of a representative of one of the state and territory environment agencies in the top order governance for the environment and NRM capability.

There are different levels to governance from the strategic to the operational, and governance mechanisms should be developed as appropriate.

Question 3: *Should national research infrastructure investment assist with access to international facilities?*

OEH supports this where it is advantageous to Australia. This is most likely to be the case where there is infrastructure that is so specialised or expensive that it is unlikely to be common, or available at all, within Australia. For example the Australian Copernicus data hub is partnering with the European Commission to access the Australian data generated by the European Space Agency Copernicus program.

Question 5: *Should research workforce skills be considered a research infrastructure issue?*

Yes as it would be unwise to invest in infrastructure if the skills to operate or use the data are lacking. Availability of the requisite skills should influence decision making about what infrastructure to support. In limited circumstances NCRIS might invest in skills development, but generally it is preferable for skills development investment to come from other sources.

Question 8: *What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?*

No specific comment, noting that there are already principles in operation which seem to work well. Any process should be open and transparent.

Question 10: *What financing models should the Government consider to support investment in national research infrastructure?*

It would seem sensible to investigate co-investment and cooperative models e.g. the Australian Copernicus data hub currently being established is an example.

Question 11: *When should capabilities be expected to address standard and accreditation requirements?*

This is critical. For data (environment and NRM) to be used for practical application by the jurisdictions, there must be clear standards and data quality control and / or assessment.

Environment and Natural Resource Management

Question 18: *Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?*

OEH agrees with the general areas for ongoing needs that are identified and also agrees with the highlighted emerging trends. Some additional comments are provided below about specific areas of interest to OEH.

Research infrastructure to support **air quality science** is not included in the roadmap document and would be of value including:

- Use of sensors to measure sources (e.g. vehicle traffic and shipping movements), local meteorology (e.g. temperature, wind, humidity), air quality (e.g. particles, nitrogen dioxide) and exposure (e.g. pedestrian traffic). The Array of Things in Chicago is an example of an urban sensing project recently funded by the US National Science Foundation. These data would be used for sophisticated air quality models to enable understanding and prediction of anthropogenic and natural impacts on air quality. This is of national relevance as there is a national agreed commitment to improving air quality.

Suggested additional research infrastructure needs in **marine and aquatic research** include:

- Improved fundamental data sets such as metocean data (e.g. waves), climate projections, and mapping data (e.g. bathymetry, geology, habitat). For example, IMOS's observation networks, data and information systems could be complemented or extend into inshore coastal waters including embayments and estuaries, and observations of shoreline changes. This would include physical, biogeochemical and biological observations, as well as high resolution mapping of marine and estuarine areas to support improved modelling of coastal systems and hazard assessments.

- sustained coastal observations to underpin coastal risk assessments and climate change shoreline forecasting, including consideration of coastal erosion and inundation.

- Initiatives to improve access to data such as the Australian Ocean Data Network (AODN) are extremely valuable to realise the vision of an interoperable, online network of marine and coastal data resources supporting science, education and management needs.

- a nation-wide forecasting and assimilation capability in the coastal and shelf seas, building on programs such as Bluelink, SEA-ROMS, e-reefs, and more broadly the Australian National Shelf Reanalysis, would be very valuable. This would support management and enhance climate predictions, including representations of locally/regionally significant extreme events and processes (eg local wind fields and tropical cyclones).

Suggested additional research infrastructure needs in **biodiversity data (vegetation, fauna and soils):**

There will be an ongoing and rapidly increasing data volumes and demand for terrestrial earth observations from both airborne and space-based platforms that need to be collated and processed

in a consistent, timely and efficient manner. This is expected grow to multi-petabytes per annum of processable data that needs to be stored, geoprocessed and managed in perpetuity.

Remote sensed imagery has a very wide range of research applications and potential end users but accessibility is constrained by network capacity and data acquisition costs. Approaches to address these limitations, such as use of remote access login and modelling at the NCI rather than enabling faster network capacity or pathways to download data for localised application, could be extremely valuable.

Infrastructure to deliver greater spatial and temporal coverage of biodiversity survey data is extremely important. This will support research on a range of important evolutionary and ecological questions such as: the resilience of Australia's ecosystems; the adaptive capacity and adaptive response of Australia's biodiversity to pressures including habitat loss and climate change; measuring Australia's progress towards internationally agreed targets e.g. the Aichi targets (https://www.cbd.int/sp/targets/). NSW OEH is working towards development of essential biodiversity variables, consistent with the international approach. The potential for national agreement on essential environmental variables is flagged in the consultation document, and OEH agrees a national approach would be valuable.

The emergence of affordable and high capability drone technology, sensors and citizen science present new opportunities for biodiversity survey. New standards will be required for data formats, geo-positioning and sensors. Facilitating and harvesting of observations including imagery of biota (presence and absence) is increasingly important

Development of national standards and systems for collection, storage and sharing of soil information would be very beneficial. The NSW SALIS and eSPADE databases already contribute to ASRIS, CSIRO's national scale soil information system. OEH strongly supports national data sharing arrangements, and standards for data collection and mapping.

New infrastructure using **sensor technology**:

OEH strongly supports the development of new automated sensor technologies.

For example effective environmental water management presently relies on ecosystem monitoring using techniques ranging from remote sensing through to labour intensive observation and measurement. Monitoring and evaluation effort will be required to continue long into the future to facilitate adaptive management of environmental water and would be significantly advanced by increased availability of automated monitoring of key indicator variables.

OEH is also very interested in automated sensor technology for the terrestrial environment, including visual sensors with feature recognition software to enable automated monitoring of fauna populations.

These initiatives will all require world-class national computational infrastructure and database systems.

National collections and facilities:

Access to long term collections and archives becomes increasingly important in understanding environmental change. While CSIRO do maintain a number of national collections, it is not apparent to OEH that there is any national strategy for considering the research infrastructure value of such collections. There is therefore a risk that individual collections may be subject to ad hoc protocols and uncertain funding futures. For example, CSIRO and a number of jurisdictions including NSW hold archives of soil samples, which are proving increasingly valuable for studying and monitoring changes in soil carbon and OEH is currently seeking to align the NSW soils archive with the national soils archive at CSIRO.

If a national strategic plan for environmental and NRM research capability and infrastructure is developed, we recommend that the value of long term collections is considered as part of any such plan. This is not a recommendation that NCRIS should fund such collections. Rather it is a recommendation that such collections might have greater value if embedded in a broader national infrastructure framework.

Question 19: *Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?*

Question 20: *Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?*

See executive summary above.

Underpinning Research Infrastructure

Question 30: *Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?*

We encourage NCRIS to continue to support and collaborate with state agencies to harmonise and better integrate state based infrastructure. The current work on improving integration between NSW BioNet, ALA and AEKOS is a good example.

Question 31: *Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?*

We suggest engagement with the US Geological Service future directions and capabilities for the LANDSAT series of satellites.

Question 32: *Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?*

We strongly encourage recognising and considering the current state infrastructure and capabilities in developing opportunities for collaborative processing and access.

Data for Research and Discoverability

Question 33 *Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?*

OEH very strongly supports the identified need for better managed research data. As noted earlier, this is one of the greatest existing limitations to effective use of existing environmental data. OEH recommends strong consideration of the value that can be gained from investing in better data management and data infrastructure, compared to the value obtained from investing in new infrastructure to generate new data.

Table 1: Environmental data

Data type	Primary source of data for NSW	Linkages to NCRIS	Important data gaps	Future opportunities and national linkages	Applications
Fauna & flora sightings	Observations (BioNet)	Sightings provided to (ALA). OEH does not currently receive data from ALA or AEKOS.	Citizen Science data from ALA is currently not incorporated into BioNet. Tracking of fauna movements.	A national approach to species distribution and occurrence mapping.	Prioritisation of investment in threatened species, conservation recovery and conservation regulation tools eg Biobanking, property vegetation planning, forestry regulation.
Fauna and flora survey	Surveys conducted by government staff and consultants and held in the BioNet system.	OEH supplies ecological survey data to the Advanced Ecological Knowledge and Observation System (AEKOS).	National field survey standards and tools.	Improved governance to facilitate greater data sharing.	Similar to above. Prioritisation of biodiversity investment. Planning decisions.
Vegetation condition	Benchmarks measured in BioNet.	None.	NSW is currently developing new benchmarks.		Similar to above. Prioritisation of biodiversity investment. Calculation of biodiversity offsets.
Taxonomic names	NSW taxonomic names managed in BioNet	None.	A national taxonomic names list.	NSW to align with a national system.	Underpins all species assessment tools.
Coastal surveys	Surveys by government staff	OEH supplies data to IMOS via the Australian Ocean Data Network (AODN)	Greater spatial and temporal coverage of beaches and estuaries through LIDAR and Aerial photogrammetry; subtidally many systems unsurveyed – systems with data are spatially & temporally limited;	Coastal observatory. NSW Coastal Reforms package will deliver marine LIDAR (LADS) across the state <20m water depth. IMOS and National Marine Science Plan actively focusing on growth in observing over the coast.	Data underpins coastal hazard and risk mapping.
Wave data	Offshore waverider via contract with Manly Hydraulics Laboratory; nearshore surveys by government staff; IMOS wave and current radar Coffs Harbour	Offshore waverider data supplied annually to AODN (IMOS) & used by RAN/BoM; nearshore data only recently started to be collected	Offshore data is limited spatially to 7 locations but 30 yrs dataset. Nearshore areas are covered by transform models - data limited both spatio-temporally	NSW Wave data collection not linked to NCRIS directly – OEH is collaborating with SIMS and NSW IMOS on wave data; Waves are identified as a significant gap in the IMOS Plan (2017-2021) and National Marine Science Plan.	Validate and improve nearshore wavemodels and assessments of coastal risk; contribute to improved ocean forecasting by BoM

Data type	Primary source of data for NSW	Linkages to NCRIS	Important data gaps	Future opportunities and national linkages	Applications
Near shore bathymetry and habitat	Surveys by government staff	OEH supplies data to IMOS via the Australian Ocean Data Network (AODN)	Only 15% of the coast is currently mapped	NSW Coastal Reforms Mapping program – sediment compartments; National Plan for Multibeam Acquisition; mapping is identified in the National Marine Science Plan; The NESP Biodiversity Hub.	Mapping for 1) understanding nearshore sediment distribution for modelling coastal hazard and risk 2) the nature and extent of marine habitats to support management by the Marine Estate Management Authority and adjacent Commonwealth Marine Reserves 3) bathy for modelling coast and ocean dynamics for the National Shelf Reanalysis.
Coastal Ocean Biogeo-chemistry (BGC)	Monthly monitoring by OEH staff at the National Reference Station Transect; onboard underway data collection	National Reference Station is majority funded by IMOS with co-investment by OEH; Bioplatforms Australia Marine Microbe Project	BGC data collected at Port Hacking since 1945; very limited in spatial extent – no routine monitoring of nearshore waters elsewhere in the state; OEH underway systems collect BGC data opportunistically	IMOS ongoing commitment to National Reference Stations; potential rollout of Marine Microbes (Bio platforms) across the NRS network	Long-term monitoring of nearshore ocean biogeochemical properties and Essential Ocean Variables (EOVs) that are of State, National and International significance. Ground-truthing ocean colour for indicators of coastal productivity and eutrophication; Data assimilation for on-shelf and nearshore regional models (hydrodynamic and ecological) – operational models for decision making)
Soils	Soil and Land Information System (SALIS)	Australian Soil Resource Information System (ASRIS)	1:100 000 scale coverage available for the whole state.	National standards for soils data collection. Overarching protocol and mapping guidelines would be beneficial.	Identify biophysical strategic agricultural land for land use decisions.
Air Quality	NSW air quality monitoring network and ANSTO Aerosol Sampling Program (ASP)	None currently	Continental scale particle composition, origin and chemistry	National background air quality and particle speciation network	Improved understanding of particle characteristics for human health interventions. Improved estimation of climate radiative forcing from continental particle emissions. Improved understanding of landscape processes such as fire and erosion.

Data type	Primary source of data for NSW	Linkages to NCRIS	Important data gaps	Future opportunities and national linkages	Applications
Climate	Bureau of Meteorology, CSIRO, NSW regional climate modelling (NARCliM)	Australian Community Climate and Earth System Simulator (ACCESS), super computing	Climate extremes and regional climate drivers.	ARC Centre of Excellence for Climate Extremes, ARC Centre of Excellence for Climate System Science, NESP earth system science hub.	Improved understanding of natural hazards and climate drivers to assist building national resilience.

Case study 1 of new capability of national benefit with opportunity for coinvestment*:*

Coastal Observatory to provide research data to better understand and track coastal erosion risk exposure.

Relevance and Importance:

The First Pass Assessment of Climate Change Risks to Australia's Coast (2009) showed considerable risk to both society and the environment from coastal hazards.

Much of the Australian coastline is potentially erodible: the Smartline coastline characterisation found that over 60 per cent of the Australian coast is composed of either sandy or muddy shores, and nearly half of these shores are backed by soft sediments, making them potentially mobile.

However, there is a *paucity of data to characterise beach responses at spatial and temporal scales corresponding to the littoral processes that affect coastal risk exposure*. This data gap constrains knowledge of coastal processes and limits the development and validation of existing and future coastal response models. Therefore, a coastal observing system is required to provide data to the marine and climate science community, other stakeholders and users, and international collaborators. The Integrated Marine Observing System (IMOS) demonstrates a suitable delivery model.

The National Marine Science Plan (2015-2025) recognised the need to "better characterise …… coastal morphologies and environmental processes" under its Urban Coastal environments Grand Challenge. The plan also recognised the need to "improve data coordination and discoverability of coastal data from multiple sources" and to "develop, test and apply methods to mitigate the impact of coastal hazards".

Significant benefits flow from an improved understanding of coastal hazards and the ability to predict and track risk exposure. A coastal observatory will provide greater certainty for business, property owners, and local communities, as well creating the ability to track and contain risk exposure through informed planning and focused management. Infrastructure requirements: a combination of infrequent spatially extensive coastal surveys (e.g. LIDAR), plus high frequency observations at a limited number of national reference sites (e.g. camera/laser scanner) to track shoreline position and beach/dune profiles near shore bathymetry (marine LIDAR) along priority coastlines where key environmental assets, property and infrastructure may be at risk; high resolution near-shore wave monitoring and modelling which can be linked to climate change scenarios; tertiary sediment compartment mapping (one-off) to facilitate management at relevant management scales determined by coastal processes.

NSW could be a test case with strong opportunity to co-invest with a core of existing state-wide wave and coastal data. Coastal observation systems have been identified as a priority extension of IMOS noting that NSW government is already a strong IMOS partner.

Case study 2 of a proposed cooperative model for data storage, access and application:

Australian Copernicus Regional Data Hub.

Geoscience Australia has an agreement with the European Space Agency to cooperate to ensure data from the EU's Sentinel satellites are accessible in Southeast Asia and the South Pacific (see http://bit.ly/2cyr459). As part of a national approach to space based imagery, CSIRO, Geoscience Australia and the NSW, WA & QLD state governments have committed to contribute to a National Copernicus Data hub for Australasia.

As part of the collaboration, the plan is for QLD to process, store and supply imagery for NT and SA and NSW will supply the same level of service for Victoria and Tasmania.

The two Commonwealth agencies will addressing national and Australasia (NZ, Antarctica and SE Asia) requirements.

The NCI (national computational infrastructure) is the landing point for data downloaded from the European Space Agency Copernicus high speed data access infrastructure and the state nodes will download their data via the Australian research network (AARNet).

"By enabling multiple user groups, from multiple countries, to come together and 'work around' such a comprehensive set of data, we are helping to make sure the full potential of the EU's amazing programme is realised and that regional partners can find regional solutions to regional challenges.

The cooperation will also make it easier for European and Australian experts to collaborate on the calibration and validation activities that are fundamental to ensuring that users have access to high-quality satellite data and value-added products they can trust." Dr Adam Lewis, GA