Final Report Project 4.1

Dynamically transforming environmental assessment through a shared analytics framework: Bowen Basin case study

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CRC TiME
Transformations in Mining Economies

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AusIndustry
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Bowen Basin mining operations
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We acknowledge the traditional custodians across all the lands on which we live and work, and we pay our respects to Elders both past and present.

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Abbreviations

BoM	Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Australian Department of Agriculture, Water and the Environment
DBS	Database system
DES	Department of Environment and Science
DOR	Department for Natural Resources Mining and Energy
DRDMW	Department of Regional Development, Manufacturing and Water
EA	Environmental Authority
EIS	Environmental Impact Statement
REMP	Receiving Environment Monitoring Program
RiVERS	Regulatory Information, Visualization, Estimation and Reporting System
SAFE	Shared Analytical Framework for the Environment
SIR	Spatial Information Repository
ToR	Terms of Reference
QGODP	Queensland Open Data Portal
WABSI	The Western Australian Biodiversity Science Institute
WaTERS	Water Tracking and Electronic Reporting System
WMIP	Water Monitoring Information Portal

Executive Summary

The CRC for Transformations in Mining Economies (CRC TiME) undertakes social, environmental, economic and technical research in direct collaboration with industry and community partners to define pathways to a prosperous and sustainable post-mining future. It is an ideal vehicle with which to establish multi-party and multi-disciplinary research approaches but access to data will be one of the most limiting factors. Establishing efficient pathways for data collection at a range of scales will ensure CRC TiME projects can deliver their objectives.

The Shared Analytic Framework for the Environment (SAFE) (WABSI, 2021) provides a nationally consistent framework to design and build the data and analytic capabilities that will support assessment of bioregional cumulative impacts, and as such, is of critical interest to CRC TiME. The project concerns a case study undertaken in the Bowen Basin to determine the gaps and opportunities related to the implementation of SAFE in Queensland. It was developed in collaboration with the SAFE project team, representatives from the Queensland Department of Environment and Science (DES) and representatives from industry (Queensland Resource Council and resource sector companies). The objectives were to:

- Document the status of current processes for data submission to the Queensland government, outlining types, formats, storage locations and access protocols.
- Document the status of data submission to Queensland government data repositories by resource companies and identify gaps or items for improvement.
- Identify challenges faced by resource companies with respect to data submission.
- Propose a pathway for incremental improvements that can be implemented by resource companies.
- Develop a plan for improving data coherence at Queensland State and Commonwealth levels that will support data access by a range of stakeholders, from regional to national level.

The methodology was informed by feedback from the steering committee. It involved an in-depth review of four Environmental Impact Studies (EIS) to identify the information that is currently collected by resource companies and characterise the associated data in terms of type, format, storage location, access protocol. The study was also supported by extensive stakeholder engagement to gather information about data system architecture, data submission and transfer processes, and about experiences with data acquisition and generation as part of an EIS process.

The main findings from this study are:

- The existing Queensland data systems are equipped to accept data collected as part of EIS, but integrating this data into the existing infrastructure requires data models that specify minimum requirements for the data, data format, data validation and metadata capture.
- There are opportunities to collect additional data for most biophysical aspects, including air quality data, but the greatest opportunities are related to acquisition of water-related data.
- Submission of water-related data might require an update to legal obligations. Feedback received from industry representatives was that data submission would need to become a compliance requirement.
- The pathways for submitting data are well identified but the lines of responsibilities for managing the corresponding databases are not always clear and are in general complex. There is an opportunity to reconsider the structure for the governance of data systems.

Finally, for each biophysical aspect (biodiversity, surface water, groundwater, air quality), guidance is provided to guide data integration in the Queensland data systems, which will contribute to achieving the objectives of SAFE.

Recommendations are to:

- Rely on subject matter experts in research, government and industry to collaboratively develop effective data models for biodiversity and water data submission. This will present a range of challenges, particularly in aligning legal requirements from various jurisdictions.
- Capitalise on existing data systems and ensure appropriate resources are allocated to achieve the level of improvement that will be required to accept data submitted by EIS proponents. The surface water database WaTERS has been outlined as potentially requiring the most significant investment.
- Recognise that achieving seamless data submission processes will be a challenging project, requiring extensive engagement and effective collaboration.

Key Words: *Data infrastructure, data management, spatial data, environmental data, data sharing*

1 Introduction

1.1 Shared analytical framework for the environment (SAFE)

The CRC for Transformations in Mining Economies (CRC TiME) is undertaking social, environmental, economic and technical research in direct collaboration with industry and community partners to define pathways to a prosperous and sustainable post-mining future. Collaboratively building a shared vision of post mine options will require assessment of the environmental, social and economic benefits that can be achieved at regional scale.

A Shared Analytic Framework for the Environment (SAFE) has been developed by The Western Australia Biodiversity Science Institute (WABSI) and the Commonwealth Department of Agriculture, Water and the Environment (DAWE). This framework provides a structured way to plan and align the data capabilities required for environmental analysis and assessments generally. Description of the framework is available at:

https://wabsi.org.au/wp-content/uploads/2021/07/SAFE-Guide-V1.1P.pdf (WABSI, 2021b)

The framework is organised in what is referred to as SAFE Tiers: Culture, Collect, Curate, Integrate, Analyse, Decision Support. These are described in Figure 1.

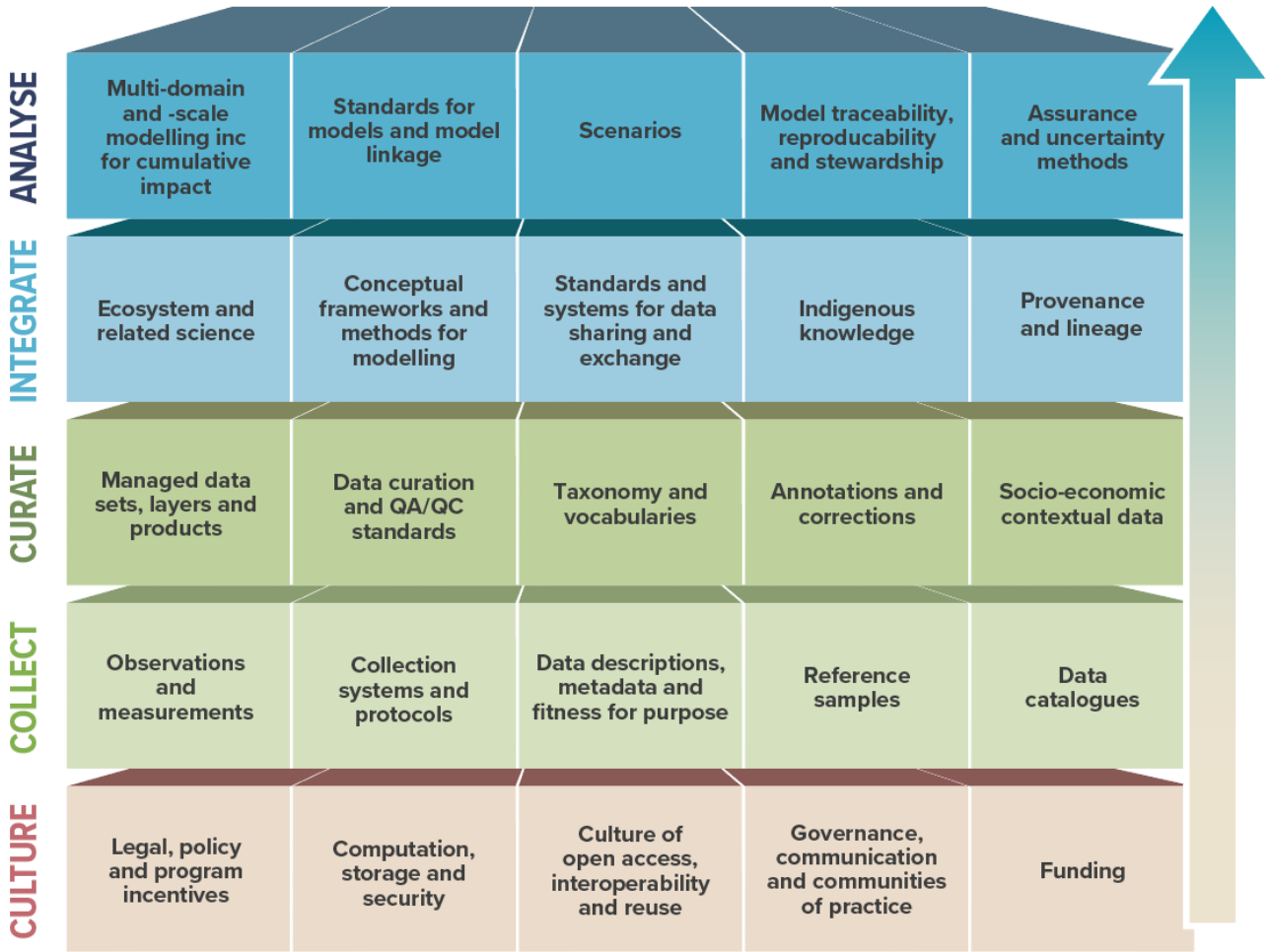


Figure 1: Illustration of SAFE framework showing tiers and associated capabilities (WABSI, 2021).

The overarching SAFE programme is developing an approach to highlight how a shared digital analytic framework could enhance collaboration and efficiency across the environmental impact assessment (EIA) process, and improve and sustain environmental outcomes including:

- Improve & sustain environmental outcomes, via:
  - Cumulative regional impact assessments.
  - Ongoing data management to enable continuous environmental monitoring.
- Assist organisations to meet their ESG objectives, via:
  - Pre-defined and consistent reporting.
  - Improved public trust and transparency.
- Increase investment certainty and efficiency, via:
  - Rapid current state regional assessments.
  - Access to data and models as input into Environment Impact Assessment.

1.2 CRC TiME and SAFE

The Western Australian Biodiversity Science Institute (WABSI) has led a strong collaboration of senior stakeholders from industry, government and the science research community to build a data sharing culture and to enhance the access, aggregation, interpretation and management of biodiversity information collected in Western Australia. The collective efforts, captured in the WABSI (WABSI, 2019) report *Digitally Transforming Environmental Assessment*, recommended the development of more efficient information flows and tools to aid environmental assessment.

WABSI, together with partners and stakeholders, consequently developed The Shared Analytic Framework for the Environment (SAFE). SAFE enables us to better understand the cumulative environmental impacts of an action, on a region, over time. It will accelerate the move to devolved robust, repeatable and transparent decision making for environmental assessments. This will:

- Reduce risk for investors, as they will be better able to understand the impact of, and to develop mitigation strategies for, activities that they propose to undertake.
- Remove duplication between regulators at different levels of government.
- Provide public reassurance about the quality of decisions.

SAFE helps individual projects determine the capabilities that they need and prioritises effort across the information and analytic supply chain that supports national decision making. The WABSI (WABSI, 2021) report *A Guide to a Shared Analytic Framework for the Environment* further explains the Framework and its benefits.

This CRC TiME project is concerned with a case study undertaken for the Bowen Basin in the context of the SAFE framework and its ability to support the mining industry to conduct dynamic environmental assessments and management. In collaboration with government and industry partners, it explored how data sets held in the public domain can be supplemented with data collected by resource companies. It also identifies opportunities for streamlining data coherence between Queensland and Commonwealth Government data management systems and some of the benefits that will result from streamlined data access and sharing.

1.3 Objectives of Bowen Basin case study

The objectives of the CRC TiME Bowen Basin case study were developed in collaboration with the project's steering committee, who included representatives from the Federal Government (Department of Agriculture, Water and the Environment (DAWE)), the Queensland Government (Department of

Environment and Science (DES)) and industry (Queensland Resource Council). Several meetings and interviews were held to gather feedback and outline the requirements, which were to:

- Document the status of current EIS processes for data submission to the Queensland government, outlining types, formats, storage locations and access protocols.
- Document the status of EIS data submission to Queensland government data repositories by resource companies and identify gaps or items for improvement.
- Identify challenges faced by resource companies with respect to data submission.
- Propose a pathway for incremental improvements that can be implemented by resource companies for data collection and submission.
- Suggest a framework for improving data coherence at Queensland State and Commonwealth levels that will support data access and integration by a range of stakeholders, from regional to national level.

1.4 Methodology

The Queensland Government already maintains extensive data sets that can support a wide range of environmental assessments and associated research projects. The methodology was developed to focus on identifying gaps and potential improvements, relying on engagement and interviews with key stakeholders and gathering evidence of the status of data submission by reviewing recent Environmental Impact Studies. Project tasks included:

- Compiling an overview of data repositories held and maintained by the Queensland government, which was achieved by organising meetings with the DES Science Delivery and Knowledge team, DAWE, and industry EIS and closure leads/representatives (Section 3).
- Reviewing recent submitted EIS for resource projects in the Bowen Basin, covering the coal seam gas (CSG) and mining industries, to determine information and data requirements, in terms of type, format, storage location, access protocol (Section 4).
- Analysing the potential for this information and data to support regional environmental assessment models (eg. cumulative impact studies); to identify key environmental values and to determine the pressure on these values, both existing and from forecasted projects (Section 5).
- Compiling research findings to provide recommendations to address key gaps and opportunities (Section 6).

The steering committee agreed that the project would deliver:

- D1 – High level map of existing Queensland government EIS data systems, outlining the potential for integration or communication with other tools and systems (Section 3).
- D2 – Overview of data currently collected by resource companies as part of EIS processes and storage locations, outlining gaps and opportunities for improving data management capabilities (Section 4).
- D3 – Benefit and value of EIS data collation and sharing by resource companies (survey type, location, volumes, cost), outlining the benefits of capturing them in Queensland systems (Section 5).
- D4 – Issues and challenges for EIS data collation and sharing and potential framework for integration and communication (Section 6).

2 Background

2.1 Queensland regulatory framework for resource developments

Queensland has established a comprehensive governance framework to oversee the development of the state's mineral and gas resources, which must comply with several items of legislation, both at Commonwealth and State level. An overview of key legislation is provided in Table 1.

In very broad terms, for resource extraction activities, the regulatory framework aims at (1) managing the direct impact of extraction activities, administered by relevant government departments; (2) guaranteeing the sustainable management of water resources; and (3) protecting nationally and internationally important flora, fauna, ecological communities, heritage sites.

All applications for coal seam gas (CSG) production, gas pipeline and liquefied natural gas (LNG), mining and processing plant projects are subject to an environmental impact statement process (EIS) (https://www.qld.gov.au/environment/pollution/management/eis-process).

Table 1: Commonwealth & Queensland legislation relating to development of petroleum, minerals and coal resources.

LEGISLATION	DESCRIPTION	ADMINISTERING DEPARTMENT
COMMONWEALTH LEGISLATION		
Environment Protection and Biodiversity Conservation Act 1999 **(EPBC Act)**	Protection and management of nationally and internationally important flora, fauna, ecological communities and heritage places (matters of national environmental significance). Has a specific trigger related towater resources in relation to CSG development	Australian Government Department of the Environment and Energy
Water Act 2007 **(Water Act)**	Management of water in the Murray–Darling Basin. Catchments for this basin in Queensland are Paroo, Warrego, Condamine–Balonne, Moonie and Border Rivers. These catchments overlie the Surat Basin	Australian Government Department of Agriculture and Water Resources
Native Title Act 1993 **(NT Act)**	Recognition and protection of native title, and requirements for Indigenous land use agreements	Attorney-General's Department, Australian Government Department of the Prime Minister and Cabinet (Indigenous Affairs)
Industrial Chemicals (Notification and Assessment) Act 1989 **(IC Act)**	Notification and assessment of the use of industrial chemicals in Australia	Australian Government Department of Health (through the National Industrial Chemicals Notification and Assessment Scheme)
QUEENSLAND KEY LEGISLATION		
Petroleum Act 1923	Regulates certain petroleum and natural gas activities. The *Petroleum and Gas (Production and Safety) Act 2004* supersedes this act, but an amended version of the *Petroleum Act 1923* was retained so that existing permit holders' existing rights were not lost	Queensland Department of Resources
Petroleum and Gas (Production and Safety) Act 2004 **(P&G Act)**	Regulates petroleum and gas exploration tenure, safety, production and pipelines	Queensland Department of Resources
Mineral and Energy Resources (Common Provisions) Act 2014 **(MERCP Act)**	Regulates land access for mineral and energy resource authority holders. Commenced on 27 September 2016	Queensland Department of Resources

LEGISLATION	DESCRIPTION	ADMINISTERING DEPARTMENT
Environmental Protection Act 1994 **(EP Act)**	Regulates activities to avoid, minimise or mitigate impacts on the environment, and to protect Queensland's heritage places	Queensland Department of Environment and Science
State Development and Public Works Organisation Act 1971 **(SDPWO Act)**	Facilitates timely, coordinated and environmentally responsible development. Provides ability for Queensland's Coordinator-General to declare a project a 'coordinated project'. Coordinated projects require an environmental impact statement and a high level of public input	Queensland Department of State Development, Manufacturing, Infrastructure and Planning
QUEENSLAND – OTHER RELEVANT LEGISLATION		
Environmental Offsets Act 2014 **(EO Act)**	Regulates the requirements and management of environmental offsets in response to activities that cause a significant residual impact on prescribed environmental matters	Queensland Department of Environment and Science
Water Act 2000 **(Water Act)**	Regulates the sustainable management of Queensland's water resources and water supply, and the impacts on groundwater caused by the extraction of groundwater by the resources sector	Queensland Department of Resources; Queensland Department of Environment and Science
Water Supply (Safety and Reliability) Act 2008 **(WS Act)**	Regulates interactions and direct impacts associated with drinking water supply	Queensland Department of Resources; Queensland Department of Health
Waste Reduction and Recycling Act 2011 **(Waste Act)**	Regulates the production, reuse and disposal of waste materials	Queensland Department of Environment and Science
Regional Planning Interests Act 2014 **(RPI Act)**	Identifies and protects areas of Queensland that are of regional interest, and resolves potential land use conflicts. The Act protects living areas in regional communities, protects high-quality agricultural areas from dislocation, protects strategic cropping land, and protects regionally important environmental areas	Queensland Department of State Development, Manufacturing, Infrastructure and Planning
Public Health Act 2005 **(PH Act)**	Protects and promotes the health of the Queensland public. Allows for public health orders to be issued that require the removal or reduction of the risk to public health from a public health risk, or actions to prevent that risk from recurring. Allows for investigation of health complaints	Queensland Department of Health
Radiation Safety Act 1999 **(RS Act)**	Protects people from health risks associated with exposure to particular sources of ionising radiation and harmful non – ionising radiation, and protects the environment from being adversely affected by exposure to radiation	Queensland Department of Health
Work Health and Safety Act 2011 **(WHS Act)**	Provides a framework to protect the health, safety and welfare of all workers at work. It also protects the health and safety of all other people who might be affected by the work	Queensland Office of Industrial Relations, which resides in the Queensland Department of Education
Gasfields Commission Act 2013 **(GFC Act)**	Establishes the Gasfields Commission, an independent statutory body with powers to review legislation and regulation, obtain and disseminate factual information, advise on coexistence issues, convene parties to resolve issues, and make recommendations to government and industry	The commission is independent, but administrative matters are handled by the Queensland Department of State Development, Manufacturing, Infrastructure and Planning
Fisheries Act 1994 **(Fisheries Act)**	Regulates the use of waterway barriers that may affect fish movement along a waterway	Queensland Department of Agriculture and Fisheries
Forestry Act 1959 **(Forestry Act)**	Regulates activities involving the clearing of forest products and access to quarry material on state land	Queensland Department of Agriculture and Fisheries
Biosecurity Act 2014 **(Biosecurity Act)**	Provides for weed, pest animal and contaminant management	Queensland Department of Agriculture and Fisheries (Biosecurity Queensland)

LEGISLATION	DESCRIPTION	ADMINISTERING DEPARTMENT
Nature Conservation Act 1992 **(NC Act)**	Regulates the protection of flora and fauna, as well as offset requirements	Queensland Department of Environment and Science
Aboriginal Cultural Heritage Act 2003 **(ACH Act)**	Regulates activities to protect Queensland's Indigenous cultural heritage values	Queensland Department of Aboriginal and Torres Strait Islander Partnerships
Queensland Heritage Act 1992 **(Heritage Act)**	Regulates activities to protect Queensland's heritage places	Queensland Department of Environment and Science
Transport Operations (Road Use Management) Act 1995 **(TO Act)**	Regulates the transportation of dangerous goods by road; manages road use impacts; issues directions on road use, including payment of compensation	Queensland Department of Transport and Main Roads
Planning Act 2016 **(Planning Act)**	Regulates developments not conducted under a relevant petroleum tenement	Queensland Department of State Development, Manufacturing, Infrastructure and Planning

2.2 Overview of the EIS process in Queensland

The QLD EIS purpose/process in relation to resource sector is outlined in the Environmental Protection 1994 Act (EP Act, https://www.mdba.gov.au/sites/default/files/pubs/qld-environmental-protection-act-1994–01-Jan-18.PDF):

The purpose of an EIS is to:

- assess the potential adverse and beneficial environmental, economic, and social impacts of a project.
- assess the management, monitoring, and control/mitigation measures that are proposed to minimise any adverse environmental impacts.
- consider feasible alternative ways to carry out the project.
- provide information to the public about the project.
- help the administering authority make decisions on an environmental authority (EA) application for which the EIS is required.
- give information to other Commonwealth and state authorities to help them make informed decisions.
- allow the Queensland Government to meet its obligations for a single environmental assessment process under a bilateral agreement with the Australian Government.

The EIS process consists of the following stages:

1. Submission and publication of Terms of Reference (TOR): the proponent drafts the TOR and seeks public comment before it is finalised and published by the administering authority. This stage can take up to six months to complete.
2. Submission and notification of the EIS: the proponent submits its EIS to the administering authority where it is assessed to ensure it addresses the final TOR. If it is adequate the proponent seeks public comment, responds to comments and may amend the EIS. The EIS is then considered by the administering authority and decides if it is adequate. This stage can take up to 2.5 years to complete.
3. Preparation and release of the EIS assessment report: the administering authority prepares and gives an EIS assessment report to the proponent and publishes the report. This stage can take up to 30 business days to complete.

Environmental impact statements aim to document (DES website):

1. the current state of the area prior to establishment of the proposed project;
2. the conceivable impacts of the project on the area, including environmental, economic and social aspects; and
3. the measures that will be implemented to avoid, minimise, mitigate and/or offset the impacts.

This EIS documentation encompasses a **baseline assessment** of fauna and flora, soils, groundwater and surface water capturing (a) the current state of the area prior to establishment of the operation, an **environmental impact assessment** to assess (b) the impacts of the proposed operation and an **environmental management plan** to document (c) measures implemented to avoid, minimise, mitigate and/or offset impacts. Given these assessment requirements, an EIS must be supported by extensive data sets (new and historical).

The EIS may be carried out under the State Development and Public Works Organisation Act 1971 (SDPWO Act) or through the Environmental Protection Act 1994 (EP Act). A regional interests development approval (RIDA) may also be required where a resource activity is proposed in an area of regional interest.

EIS under the EP Act are administered by DES (https://www.qld.gov.au/environment) with the process outlined in Figure 2. An EIS under the SDPWO Act are administered by the Coordinator-General ('coordinated project'), Department of State Development, Manufacturing, Infrastructure and Planning (https://www.statedevelopment.qld.gov.au/coordinator-general/assessments-and-approvals).

The structure of this EIS process is outlined in Figure 3.

The proponent of a project may apply for a declaration of a 'coordinated project' under the SDPWO Act if one of the following characteristics is met for the proposed project:

- it encompasses complex approval requirements, involving local, state and federal governments;
- has potential significant environmental effects;
- has strategic significance to the locality, region or state, including for the infrastructure, economic and social benefits, capital investment or employment opportunities; or
- has significant infrastructure requirements.

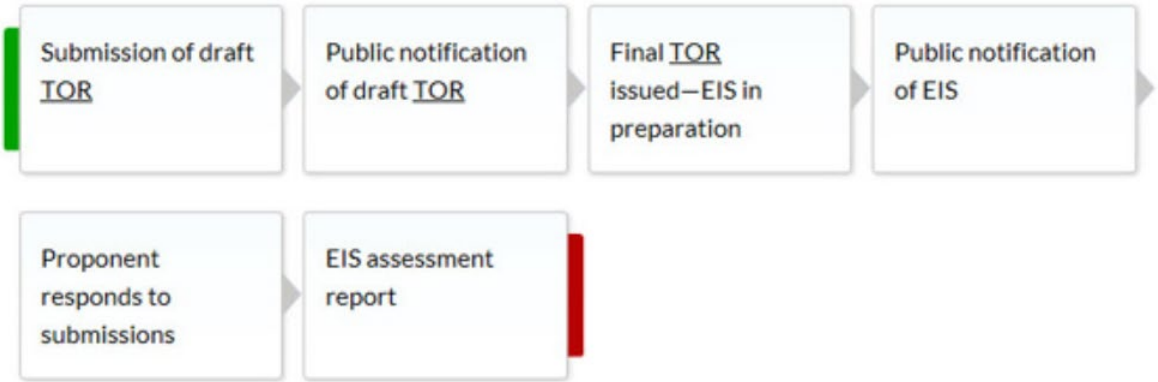


Figure 2: EIS assessment process administered by the QLD DES (https://www.qld.gov.au/environment/pollution/management/eis-process/about-the-eis-process/types-of-eis).

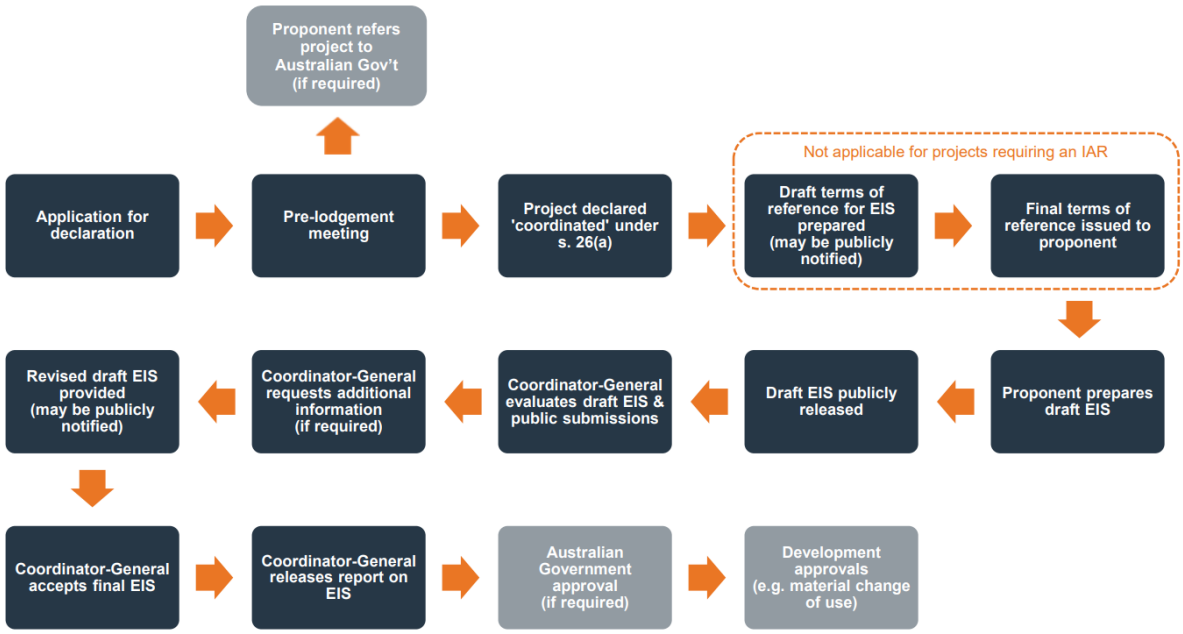


Figure 3: EIS assessment process administered by the Coordinator General (https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0011/32222/eis-fact-sheet.pdf).

2.3 The Bowen Basin region

The information providing the socio-economic and environmental context of the Bowen Basin was sourced from a study that produced a comprehensive baseline assessment of these aspects in the region (Worden et al., 2021).

2.3.1 Socio-economic context

The Bowen Basin is a major coal mining region located in central Queensland, about 500 km north of Brisbane. It is positioned as a gateway to the Asia-Pacific and has close economic ties with expanding markets in that region. The strongest industry sectors are agriculture and mining, followed by services such as health care and social assistance, retail trades, accommodation and food services, education and training.

The Bowen Basin hosts Australia's largest coal deposits, including prime coking coal. The region has a strong manufacturing base supported by the presence of equipment manufacturers, international engineering firms and ASX-listed companies. The regional economy is largely driven by the coal industry with much of the engineering and manufacturing businesses linked to mining.

There is access to three regional airports, two deep water seaports, three bulk shipping terminals and reliable freight service rail networks. There are well-established water supply schemes with trading mechanisms, excellent connection to the HV-grid, and pipeline connections to south-east Queensland. Challenges include ageing infrastructure (particularly in the areas of water, transport, telecommunications, health, power, waste), poor internet and mobile phone connectivity, housing affordability and diversity.

The region has a population of 178,227 and mining accounts for the highest percentage of employees. There is good quality primary and secondary education and high levels of trade-qualified residents. Constraints include limited opportunities outside urban centres for tertiary education, health services and employment diversity. Growing and fluctuating non-resident workforces put pressure on all spheres of community infrastructure and social cohesion in the region.

Given these assets, it can be expected that there will be continuing interest in developing proposals for expansion of the resources sector. Investment in data management capabilities can reinforce existing assessment processes and facilitate analyses of pressures and responses at regional level.

2.3.2 Environmental context

The Bowen Basin is located in the Brigalow Belt bioregion, a wide band of acacia-wooded grassland that runs between tropical rainforest along the coast and the semi-arid interior. The characteristic plant is the highly water-stress tolerant brigalow (*Acacia harpophylla*), a slender acacia tree which thrives on clay soils which once covered much of the area, especially the fertile lowlands. Most of the brigalow has been cleared for grazing and agricultural land. This has created a landscape where only relatively small tracks of endangered ecosystems and of-concern ecosystems remain.

The region has a hot to warm subhumid climate with summer-dominant rainfall (around 500 mm/year on average, with large variations from year to year). Large areas have soils suitable for agricultural systems, but the region is also characterised by a large extent of dispersive soils, which contain high levels of sodium, have a low-nutrient status and are very vulnerable to erosion and dryland salinity when vegetation is removed.

There is an abundance of natural assets in the Bowen Basin, including a climate with high solar radiation, soil attributes, in places, that are favourable to agriculture, and mostly uniform geology with generally a low risk of contaminants being mobilised (noting that there are locations in the south of the basin where mining waste can generate acid mine drainage and high levels of sulfate). The key contaminant of interest produced by mining activities throughout the basin is salt.

The region is characterised by extensive clearing of native vegetation, severe weather events (flooding, drought and bushfires), and variability in rainfall (extended dry periods) and water availability.

With these biophysical characteristics, it is expected that environmental impact statements will contain detailed assessment of potential impacts on water resources (surface water and groundwater quality and quantity), soils (types, quality, and health) and associated land capability, flora and fauna.

3 Existing EIS data systems in Queensland

The Queensland government has invested significant resources to establish a world-class data ecosystem for non-sensitive data, as documented in the Queensland Government Open Data Policy Statement (2016). As part of the statement, the Queensland Government has committed to follow the International Open Data Charter principles:

- Open by Default
- Timely and Comprehensive
- Accessible and Usable
- Comparable and Interoperable
- For improved Governance and Citizen Engagement
- For inclusive Development and Innovation.

More specific information on the current open data strategy in Queensland is available via the website of the Office of the Information Commissioner, Queensland (https://www.oic.qld.gov.au/publications/policies/open-data-strategy).

In this section, we provide a general overview of Queensland's data systems, covering multidisciplinary spatial data (Section 3.1), biodiversity (Section 3.2), surface water (Section 3.3) and groundwater (Section 3.4**Error! Reference source not found.**). The accessibility and amount of data available for the biophysical aspects vary vastly. Each section provides an overview of the general data architecture with pathways and connections, but the depth of assessment varies between sections and aspects. For example, the multidisciplinary catalogues outlined in Section 3.1 offer unrestricted public domain access to thousands of datasets, while detailed data for surface water are sparse and thus, focuses on data systems utilised in the annual submission process with which industry is expected to comply. Where possible, the individual sections outline the connections and pathways from state to federal Gov data systems.

Note that the term DBS is used extensively to refer to 'database system'.

Public domain data in Queensland are managed and curated by a number of government departments, with major involvement from:

- Department of Environment and Science (more specifically the Science & Technology Division), covering the topics of surface water and biodiversity (https://science.des.qld.gov.au/government/science-division/about)
- Department of Regional Development, Manufacturing and Water, covering the topic of groundwater (https://www.rdmw.qld.gov.au/)
- Department of Resources, maintaining general spatial data infrastructure and collating data from different departments (https://www.resources.qld.gov.au/)

3.1 Multidisciplinary spatial data catalogues

The Queensland Government Open Data Portal (QGODP, https://www.data.qld.gov.au/) is the central hub for data generated by Queensland Government Departments, company statutory reports and publications. The portal hosts over 3,000 datasets including tables, reports and spatial data accessible under the Creative Commons Attribution 3.0 or 4.0.

The Queensland Spatial Catalogue (QSpatial, https://qldspatial.information.qld.gov.au) is the central repository for spatial data in Queensland, maintained by the Department of Resources (DOR). The platform hosts data from a variety of Queensland Government Departments and private infrastructure service suppliers (e.g., SunWater). The data behind QSpatial is curated by the DOR in the Spatial Information Repository (SIR) Database System (DBS) and hosts the spatial data for the various web mapping applications, with the two major map viewer services being QLD Globe and GeoResGlobe (Figure 4). QSpatial also hosts dataset for variety of specialised web map applications, e.g., Biomaps, WetlandMaps, AgTrendSpatial and the Development Assessment Mapping System. Spatial is not connected to any system managed at Federal level.

The proponents of an EIS may utilise large parts of this spatial data ecosystem, especially for thematic mapping purposes in the baseline assessment (Section 2.2, item a, but also to provide background data for the impact assessment (item b) and management plans (item c). QSpatial holds datasets that are relevant to EIS preparation such as those related to geology, soils (soil types, soil properties such as erosivity) and land capability.

At the moment, there is no process for submitting to QSpatial data collected by proponents.

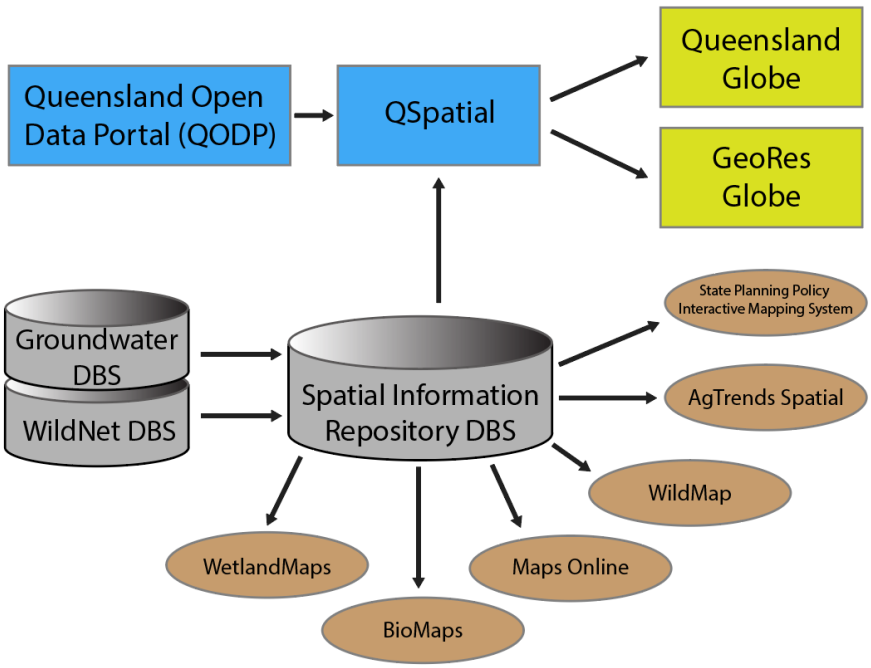


Figure 4: General public domain data system infrastructure in Queensland.

3.2 Biodiversity data systems

The WildNet DBS is the central hub for biodiversity-related data in QLD, curating biodiversity data from various sources and distributing data through the Queensland database infrastructure (Figure 5, https://www.qld.gov.au/environment/plants-animals/species-information/wildnet). WildNet contains information about over 21,000 individual species (flora and fauna), including nomenclature, conservation status, location records, species lists and associated documents.

Data are supplied into the system via the WildNet Lite installation. Examples of supplied data are surveys from Queensland Government Departments, surveys performed by external parties, permit and return data from DES. Direct data submission pathways into the WildNet DBS exist via Herbrecs DBS and Species Profile Tool (Figure 5, Herbarium).

The WildNet DBS supplies data to the Queensland Spatial Catalogue (via the Spatial Information Repository DBS, SIR) and to the Queensland Government Open Data Portal (QGODP) via the Open Data Coordinator (Figure 5). Furthermore, the WildNet DBS is also connected to WildNet which is the most important data repository for biodiversity data in Queensland. This portal is also linked to the Atlas of Living Australia (hosted by CSIRO, https://www.ala.org.au/) via the QLD wildlife data API. In summary, the WildNet DBS is well connected to a variety of biodiversity related data systems in Queensland and on Commonwealth level. It is worth noting that the connection to Commonwealth database is unidirectional: data can be transferred from Wildnet to the Commonwealth catalogue, but not the other way around.

As mentioned above, there are existing pathways for submitting data to Wildnet and there are instances where survey data collected by industry were submitted via the Herbarium.

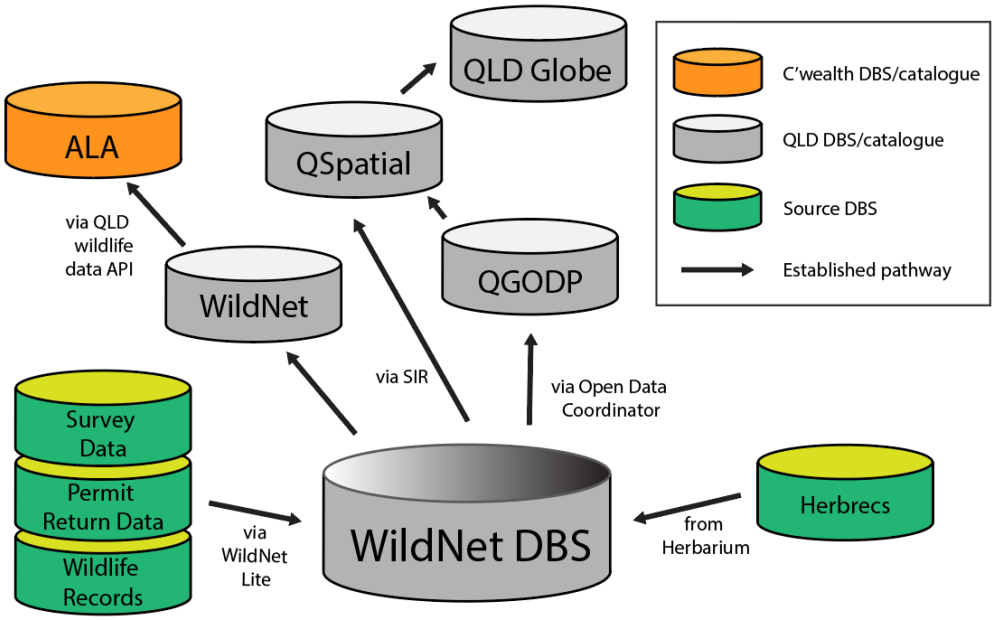


Figure 5: Data system architecture for Biodiversity data in Queensland and connections to federal data catalogues.

3.3 Surface water data systems

Surface water quality and quantity data in Queensland is collected, managed, and curated by the DES in two systems:

- Water Tracking and Electronic Reporting System (WaTERS, https://science.des.qld.gov.au/government/science-division/waters) and
- Regulatory Information, Visualisation, Estimation and Reporting System (RiVERS)

In addition, the Department for Regional Development, Manufacturing and Water (DRDMW) hosts the Water Monitoring Information Portal (WMIP). While the WMIP provides publicly accessible data, RiVERS and WaTERS are not open to the public. WaTERS is accessible for data submission for holders of Environmental Authorities (EA) and RiVERS is DES-internal data compilation platform only.

WaTERS is a data submission portal for water-related monitoring data only, allowing operators to submit their monitoring data for licensing and compliance purposes. Industries submitting data to WaTERS include wastewater treatment plants, coal mines, coal seam gas activities, and heavy industries. The database is thus not limited to collating data from the resources sector.

The portal facilitates comparison of submitted water data against site-specific environmental approval conditions, as documented in the respective Environmental Authority. The portal also allows for submission

of data that are not necessarily subject to strict compliance conditions, such as Receiving Environment Monitoring Program (REMP, https://environment.des.qld.gov.au/__data/assets/pdf_file/0014/90131/era-gl-receiving-environment-monitoring-program.pdf) data.

WaTERS is not currently setup to receive data collected as part of EIS: this would require significant updates as all data must be associated with a monitoring point listed in Environmental Authorities. With projects, such information is not available.

The submitted data is curated in the WaTERS DBS, which feeds monitoring data into RiVERS, a department internal web mapping application used to check data against regulatory conditions, such as release limits and water quality objectives (Figure 6). Data can generally be requested from the department as needed, but according to DES, requests are rare, as records for the relevant REMP data are few and far between.

In addition, the WaTERS DBS is connected to Wetland Info, which in turn feeds data into the Directory of Important Wetlands via the Australian Wetlands Database (curated by DAWE, https://www.awe.gov.au/water/wetlands/australian-wetlands-database) demonstrating established data pathways from state to federal systems. However, this connection is unidirectional.

The WMIP is a publicly available database maintained by the DRDMW and hosts streamflow and groundwater level data from government-operated monitoring locations in QLD (operated by DES and BoM, https://water-monitoring.information.qld.gov.au/). The monitoring network is checked regularly by the DRDMW to ensure he monitoring network is meeting the requirements of the *Water Act 2000* (Table 1). Data is organised by catchment basin for surface water data and by hydrogeological unit for groundwater level data. Historical data sets are included.

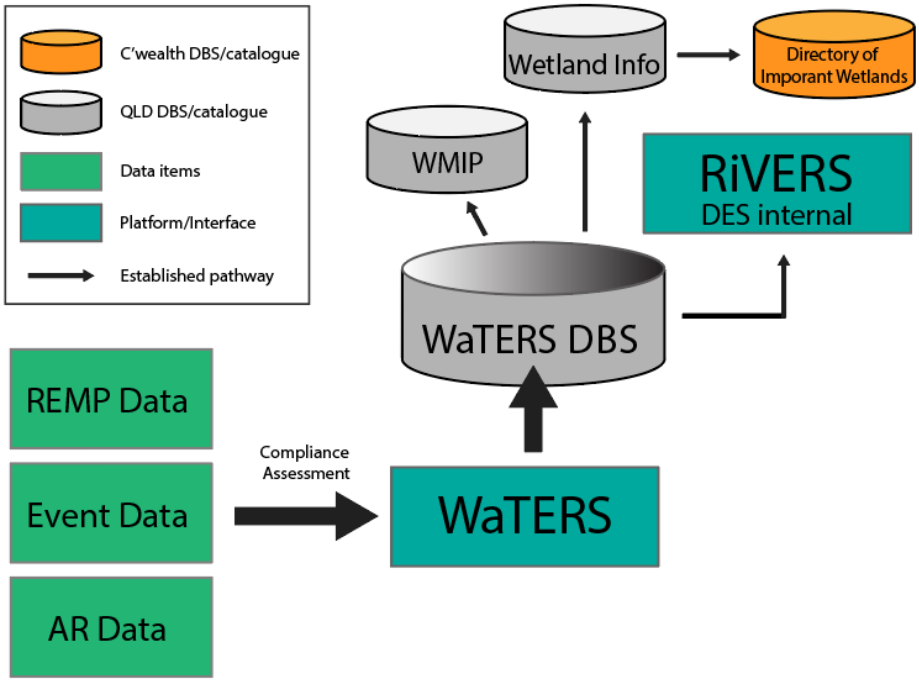


Figure 6: Data system architecture around the WaTERS DBS for industry-submitted monitoring data. Abbreviations: REMP, Receiving Environment Monitoring Program; AR, Annual Returns; WMIP, Water Monitoring Information Portal.

3.4 Groundwater data systems

The Department of Regional Development, Manufacturing and Water (DRDMW) maintains a groundwater database. It holds groundwater level data from ~300 monitoring bores and groundwater quality data from ~4,600 monitoring bores, 300 of which with loggers. The monitoring bores are managed by the government.

The Australian Groundwater Explorer hosted by BoM provides access to a wide range of groundwater data, including more than 870,000 bore locations, bore logs, groundwater levels, salinity, groundwater management areas and landscape characteristics (http://www.bom.gov.au/water/groundwater/explorer/map.shtml).

The datasets contained in the DRDMW groundwater database are updated monthly on the connected portals, QLD Globe, GeoResGlobe and QODP (Figure 7). QLD Globe allows to query the database by spatial location of groundwater bores and links to specific information for each groundwater bore, including bore report, water level time series and water geochemistry data (if available).

Groundwater data is collated and submitted under the *Water Act 2007* (Table 1) via a monthly file transfer to the Bureau of Meteorology (BoM) by the DRDMW. The *Water Act 2007* further regulates submission of surface water and water storage data that are available via the Australian Groundwater Explorer. Details of the legislative requirements governing these data submission processes are beyond the scope of this project, as they are complex.

The platform also holds a large database on groundwater geochemistry data, mainly supplied by CSIRO. The explorer allows for data extraction by querying for location, bore type, log data or specific measurements.

There is an existing pathway to submit groundwater data from the Queensland to the Commonwealth system (hosted by BoM) but it is unidirectional. The Queensland database is not currently set up to receive data from EIS proponents.

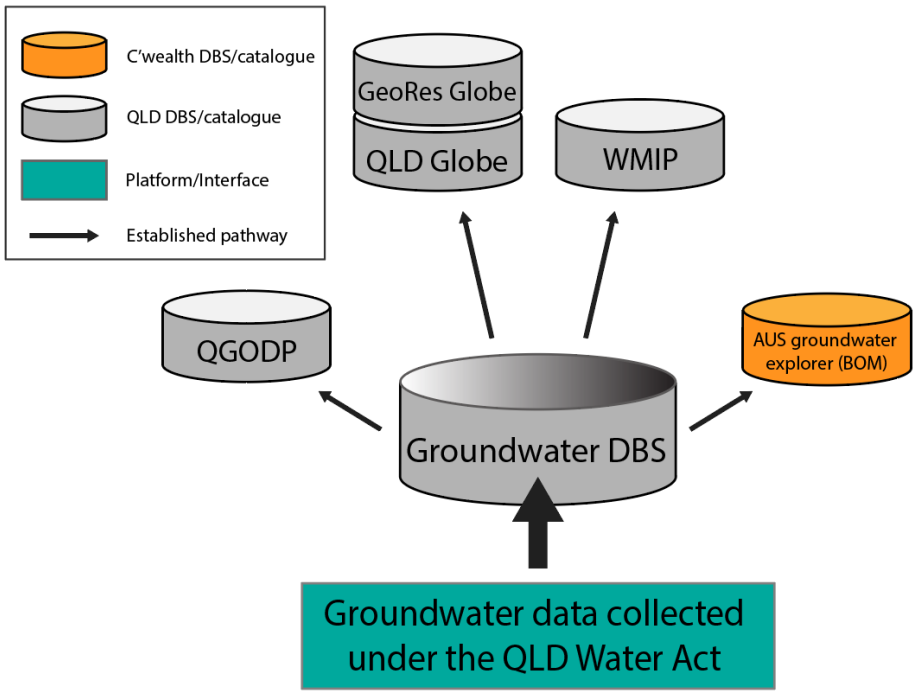


Figure 7: Data system architecture for groundwater data. Abbreviations: WMIP, Water Monitoring Information Portal; QGODP, Queensland Government Open Data Portal.

3.5 Air quality monitoring

The QLD DES, in collaboration with industry partners, operates an air quality monitoring network across the state. It can be accessed via the Live Air Data application (Figure 8, https://apps.des.qld.gov.au/air-quality).

The portal offers access to air quality time series data for monitoring stations across Queensland and can be queried by type of pollutants and downloaded as tabulated data. In addition, air quality data can also be accessed via the QODP portal, compiled by monitoring period and/or pollutant type.

Air quality information includes concentrations in particulate matter with a diameter of 10 µm or less (PM10), particulate matter with a diameter of 2.5 µm or less (PM2.5), carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide and total suspended particles. Air quality monitoring stations have been installed in south-east and south-west Queensland, Central Queensland, Gladstone, Ayr, Townsville and Mount Isa, providing a coverage for the main developed areas that present risks to air quality due to urban development or industrial activities.

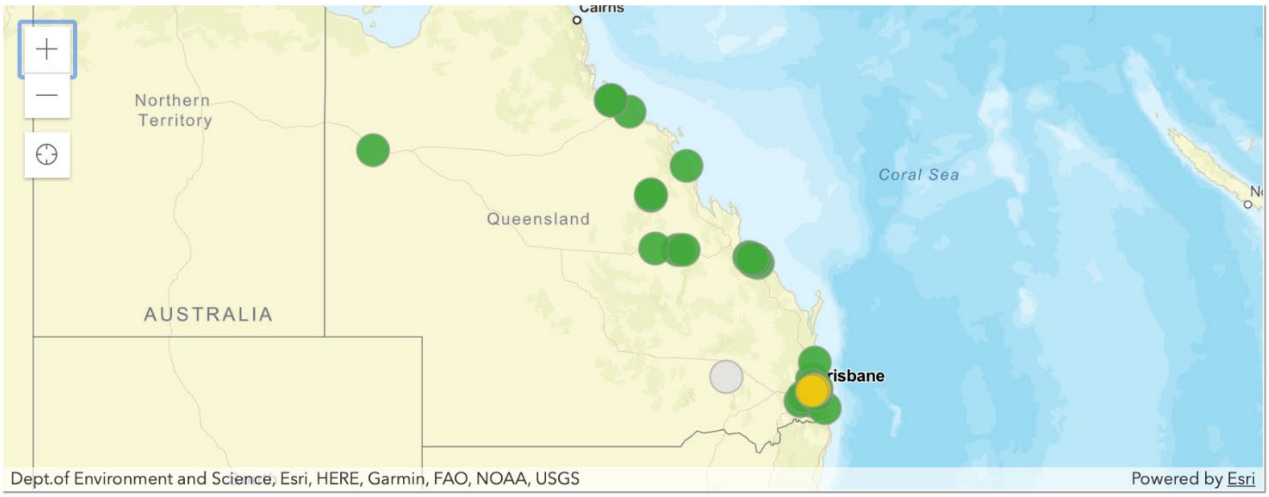
Wednesday 17 November 2021 8am Change date

Air quality | Organics | Metals | Meteorological

Air quality

Legend to air quality category colours about category values

Good | Fair | Poor | Very poor | Extremely poor



Map markers are indicative only. They do not reflect the exact location of the stations.

Select a value within the table to generate charts and to download air quality data.

South East Queensland MAP

Station	Particle $PM_{2.5}$ µg/m³ 1hr avg	Particle PM_{10} µg/m³ 1hr avg	Carbon monoxide ppm 8hr avg	Nitrogen dioxide ppm 1hr avg	Ozone ppm 1hr avg	Sulfur dioxide ppm 1hr avg	Particles TSP µg/m³ 1hr avg	Visibility Mm^{-1} 1hr avg
Brisbane CBD	6.8	21.6						14
Cannon Hill	6.7	23.9		0.003	0.024		34.6	
Deagon	5.4	13.7		0.018	0.019			20
Deception Bay	7.1	21.4		0.003	0.022			

Figure 8: Snapshot of the Live Air Data platform (accessed 17/11/2021 09:30).

4 EIS review

4.1 EIS selection in the Bowen Basin

This section provides a review of EIS focused on recently approved resources projects located in the Bowen Basin. The objectives of the review were to:

1. identify and characterise the data items generated by the proponent (resources companies)
2. summarise the public domain data that was sourced from federal and state repositories; and
3. assess differences in collected and utilised data across different EIS (i.e., local vs. regional studies, coal vs gas extraction operations).

For the purpose of this study, the steering committee agreed that four EIS that were approved recently for the resource sector (e.g. in the last 7 years) were to be reviewed. The individual locations of the project areas are mapped in Figure 9, which provides an indication of the footprints of these projects. Two were administered by the Coordinator General as they were declared a 'coordinated project' under the State Development and Public Works Organisation Act 1971, due to their complexity and strategic significance for the state (see Section 2.2):

- **Olive Downs Project**, approved in 2019: Greenfield metallurgical coal mine with a yield of up to 15 million tonnes of product coal per annum for steel production, located approximately 4 0 km south-east of Moranbah.
- **Byerwen Coal Project**, approved 2014: A 15 million tonnes per annum (Mtpa) Run of Mine (ROM) open cut coal mine project with a mine life of up to 50 years, located approximately 20 km west of Glenden.

Two projects were administered by the Department of Environment and Science (DES):

- **Arrow Bowen Gas Project**, approved in 2014: Coal seam gas extraction located west of Mackay, extending from Glenden in the north to Blackwater in the south (covering 8,000 km^2), to supply gas to the domestic market and for the production and export of Liquified Natural Gas (LNG).
- **Isaac Downs Project**, approved in 2021: Greenfield, open-cut coal mine and associated project infrastructure, extracting approximately 1 to 4 million tonnes per year of run of mine (ROM) metallurgical coal, with an approximate total of 35 million tonnes of coal over 16 years. The project location is situated 10 km south-east of Moranbah.

Reports for approved and not-approved EIS administered by the Coordinator General are accessible via the website of the Department for State Development, Infrastructure, Local Government and Planning (73 projects since 2000 as per 22/09/2021). The documentation encompasses the individual report chapters, including appendices, Terms of Reference (ToR) and the intermediate public correspondence between proponent and administrating authority in the form of a timeline. The documents related to the EIS of the two coordinated projects listed above were downloaded using this mechanism.

Access to the documentation related to the EIS administered by DES is restricted to Final ToR and to the EIS assessment report. Both are available on the Queensland Government website. Additional documentation is available via the DES Library Catalogue or upon request via the EIS Coordinator. In some cases, EIS documents can also be accessed via the proponent's website (e.g., Isaac Downs Project). Links are provided on the DES website (https://www.qld.gov.au/environment/pollution/management/eis-process/projects).

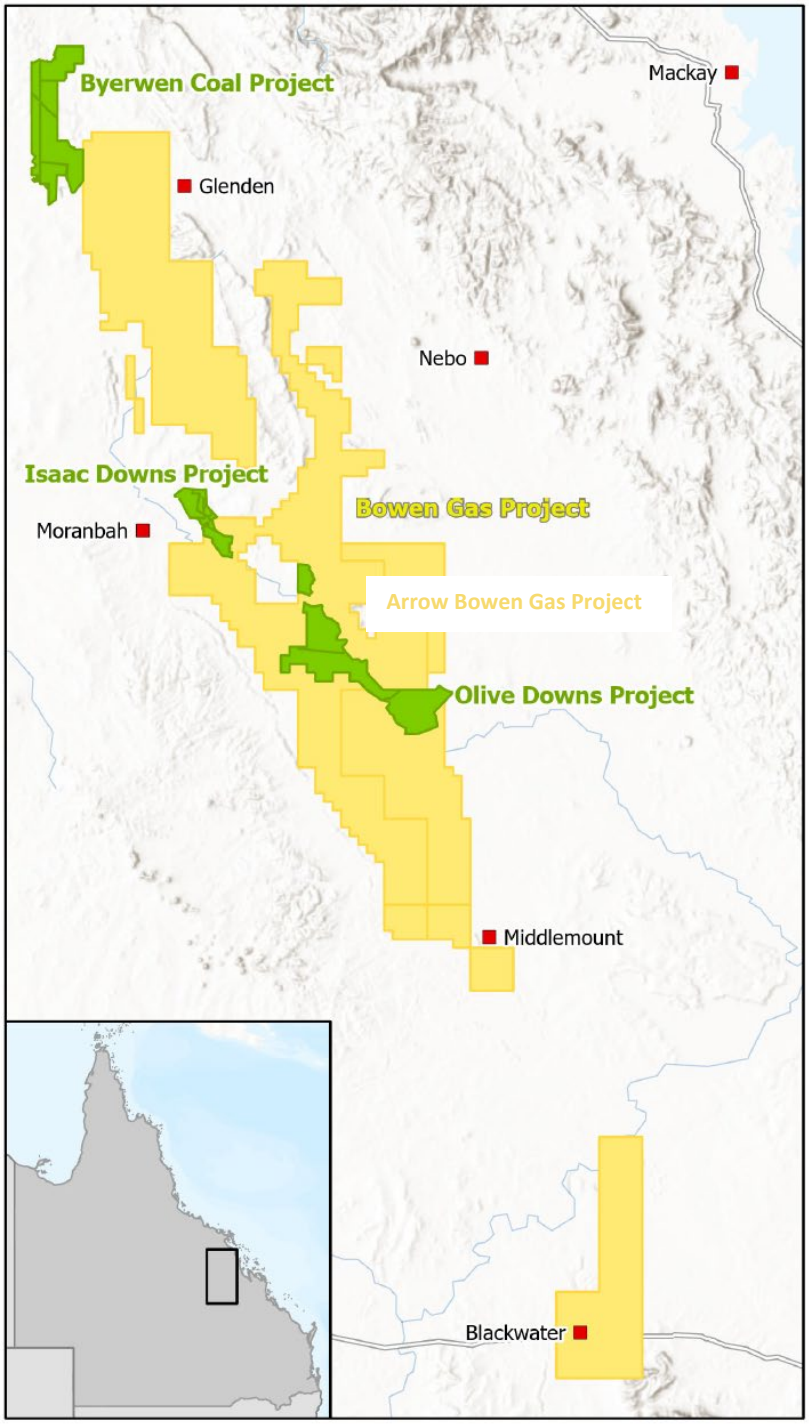


Figure 9: Locations of reviewed EIS projects in the Bowen Basin.

4.2 EIS Review

The EIS review focused on the information describing the existing environment (or baseline) and the potential environmental impacts, as these are the parts that require the largest volume of environmental input data. The information was organised into the following categories:

- land and soil
- flora
- fauna
- surface water

- groundwater
- water quality
- air quality.

For each category, the data sources and data types were identified. Data sources included:

- data collected or generated by the proponent
- data collected from public domain spatial datasets, traced back to the respective public domain data catalogues, organised in federal and state data systems.

Data types were qualified as spatial or tabulated (e.g., numeric values that can be presented in tables) and were briefly described. The spreadsheet documenting the data collation and analysis is provided in Appendix A.

4.3 Stakeholder engagement

Meetings and interviews were conducted with a range of stakeholders in Bowen Basin from government departments, operators, and consultants to determine their data needs and systems for EIS process. Interviews with government departments were focused on the data system architecture, data submission and transfer processes and pathways of data into/out of data systems. Operators and consultants were interviewed on their experience with data acquisition and generation during the EIS process.

The main findings are that:

- There is consensus from stakeholders that data in EIS are valuable and should be made publicly available.
- Operators, service providers and government departments are hesitant to publish data voluntarily where:
    - Data relate to sensitive or complex environmental topics, such as water quality data, which could be misused or misinterpreted.
    - Company or site details are not de-identified or aggregated.
    - There are access issues (see below).
    - Data submission is onerous.
- Access to data from historic EIS is currently problematic and hence datasets are not utilised to their full potential, as it would generally rely on formal and informal data sharing agreements between operators and/or service providers.
- Data validation before publication of new EIS data is critical and requires new processes/pathways to be implemented or amended of existing processes.
- Contextual information is necessary to accompany the publication of data to minimise misuse and misinterpretation.
- Most operators have (spatial) data management systems in place, following company standards on data models.
- Regulation is required to provide legal framework for EIS-data publication addressing:
    - Compliance.
    - Data submission formats and models.

- Data validation processes.

- Appropriate resourcing (for data curation) and ongoing funding is necessary to support any shift in data collection and delivery.
- There is a need for improved integration of systems across government.

4.4 Classification of EIS Data

The comprehensive review of the data supporting the four reviewed EIS shows that:

- EIS reports are exclusively documented as PDF reports with data (e.g. tabulated data, spatial datasets) encapsulated in figures and document-based tables.
- a large amount of publicly available environmental data was utilised or generated within the various subsection of the EIS (Table 2, Appendix A).
- more than 50% of data items utilised in the reviewed EIS documentation are newly generated data that are currently not captured in the data repositories of the public domain (Table 2).
- these findings are consistent for all reviewed EIS, whether they were submitted to the Coordinator General or to DES, or whether they were submitted by the gas industry or the mining industry.

Table 2: Summary of data items used and generated in four EIS approved for the resource sector in the Bowen basin in the past 7 years.

TOPIC	DATA ITEM DESCRIPTION	DATA FORMAT	PUBLIC DOMAIN DATA
Land & Soil – Baseline and Impact Assessment	Community engagement and consultation process to assess impacts	report	No
	Soil map units, sampling points	shapefile	No
	Agricultural land classes	shapefile	Yes
	Strategic cropping land trigger map	shapefile	Yes
	Pre-development cattle grazing	shapefile	Yes
	Contaminated land points	shapefile	Yes
	Soil characteristics and chemistry	spreadsheet	No
	Land ownership and aboriginal parties	shapefile	Yes
	Existing Infrastructure	shapefile	Yes
	Land suitability classes	shapefile	Yes
	Geology	shapefile	Yes
	Land Systems	shapefile	Yes
	Erosion Rating	shapefile	No
Flora – Baseline	General flora species list, threatened flora species list, scientific relevant species, survey locations	spreadsheet/shapefile	Yes (besides survey locations)
	Essential habitats, environmentally sensitive areas	shapefile	Yes
	Regional ecosystems (+field validation)	shapefile	No
	State and national matters of significance	shapefile	Yes
	Indicative development stages for biodiversity offset	shapefile	No
Flora – Impact Assessment	Clearing areas (in relation to habitat types)	shapefile	No
	Terrestrial ecology Impact statement	report	No
Fauna – Baseline	Terrestrial fauna assessment, survey locations	report/shapefile	No
	State and national matters of significance	shapefile	Yes

TOPIC	DATA ITEM DESCRIPTION	DATA FORMAT	PUBLIC DOMAIN DATA
	Environmentally sensitive areas, biodiversity significance, essential habitats, ecosystems, wildlife corridors	shapefile	Yes
	Groundwater Dependent Ecosystem mapping	shapefile	Yes
Fauna – Impact Assessment	Terrestrial fauna impact assessment/Stygofauna impact assessment (links to groundwater species)	report	No
	Fauna clearance habitat areas, habitat fragmentation	shapefile	No
Water Quality (Surface water) – Baseline	Database of physio-chemical parameters, monitoring sites, time series data	spreadsheet/shapefile	No
Water Quality (groundwater) – Baseline	Database of physio-chemical parameters, monitoring sites	spreadsheet/shapefile	No
	Groundwater quality mapping (Arrow Bowen Gas only)	shapefile	No
Water quality – Impact assessment	Water balance modelling	report	No
	Groundwater, surface water, geomorphology, geochemistry, aquatic ecology assessments (+mitigation management)	report	No
Water resources – Baseline	Catchment mapping (site scale), diversions	shapefile	No
Water resources – Impact Assessment	Water balance modelling, flood model (project phases and post mining)	spreadsheet, shapefile	No
Air – Baseline	Air quality monitoring sites + data	spreadsheet, shapefile	No
Air – Impact Assessment	Dispersion model	shapefile	No

4.5 EIS data from public domain

The individual public datasets identified in the previous section have been traced back to the data repositories and catalogues that hold the data. A summary of the most data repositories is documented in Figure 10. It should be noted that some datasets are available across multiple data catalogues, due to the closely linked architecture of some related catalogues (e.g., QSpatial, QGlobe, GeoResGlobe). The list of catalogues is subdivided into state (QLD) and federal catalogues with some catalogues having established shared data pathways from state to federal repositories (Figure 10).

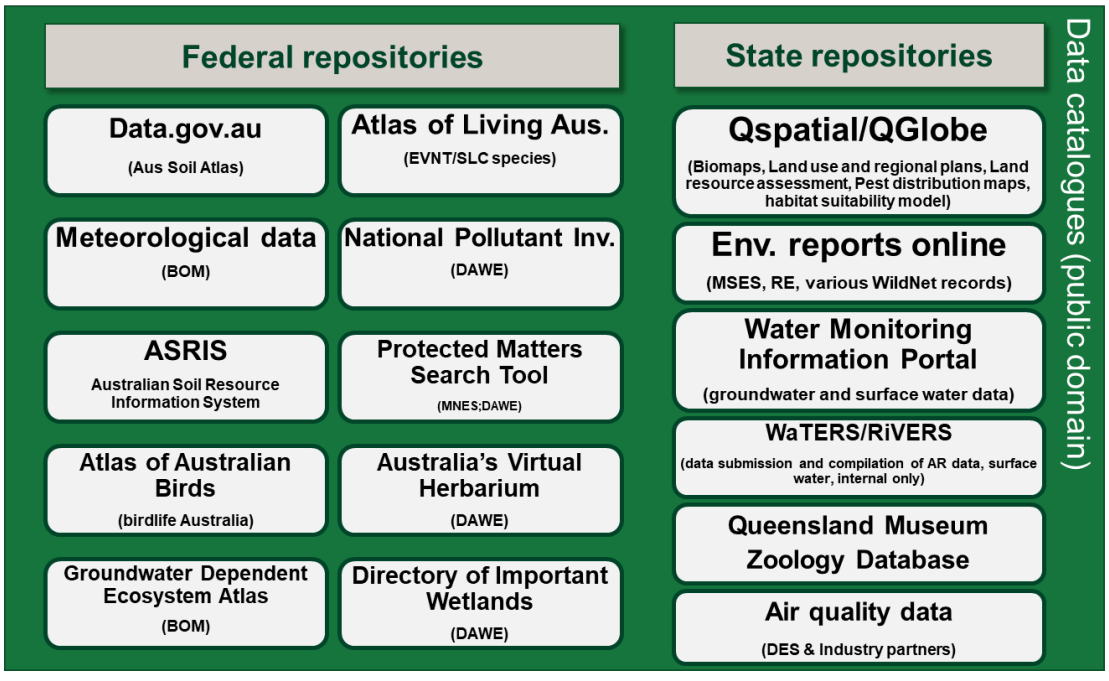


Figure 10: Data catalogues and repositories identified for the four EIS examined in this study.

5 Discussion

Key finding from the Bowen basin case study review is that data that are generated and collated for EIS processes remain encapsulated in PDF reports, with no access to the raw data files. This means that tabulated data and spatial data that were created for the EIS cannot be readily accessed by other parties. The proponent and the service providers who were involved in the data collection are the only one with direct access to these new data sets.

Our interviews with industry stakeholders involved in previous EIS projects in the resource sector in the Bowen Basin highlighted that data from historical EIS in the same area or region are highly valuable when developing a new EIS. Environmental Impact Statement contain valuable baseline data that represent reference values and can be used to assess the impact of activities on local and regional scale and are of high scientific and environmental value for all involved stakeholders.

EIS data are often inaccessible as they are held by competing proponents and their service providers. As such, they are rarely used, unless they are held within the same organisation or unless there are formal or informal data sharing agreements between the respective proponents. There are service providers who have been engaged to work on multiple EIS in a region on a specific topic and may be able to facilitate access to some data sets. However, this requires extensive engagement and agreement to data sharing conditions, which is resource intensive. Generally, agreements for EIS data sharing rely on personal contacts and are the exception rather than the rule.

Collectively, EIS collect and capture new regional data that can improve the understanding of larger scale environmental topics and associated issues.

5.1 Cost of EIS data collection

This study attempted at deriving an estimated cost for an average dataset generated for an EIS in the Bowen Basin. The extent of data collection will be dictated by the specific objectives of the EIS, which will be related to the proposed activities and their locations. As such, the derived costs are to be interpreted as broad estimates that provide an indication of the value generated by the new data.

Table 3 lists the number of survey locations and monitoring sites that were created for each reviewed EIS, along with information about the data that were collected at these locations. If costs were provided by the proponents, they are included in the table.

Table 3: Compilation of survey locations and monitoring sites from the reviewed EIS.

TOPIC	OLIVE DOWNS PROJECT	BYERWEN COAL PROJECT	ARROW BOWEN GAS PROJECT	ISAAC DOWNS PROJECT
Flora – Baseline	227 survey locations	143 survey locations	630 survey locations (surveys valued at A$ 1 m by Arrow Energy for a survey area of 50,000 ha	38 detailed secondary sites
Fauna – Baseline	225 general survey locations, 13 trap sites	35 general survey locations, 13 trap sites	334 general survey sites, 39 trap sites (surveys valued at A$ 1 m by Arrow Energy for a surveyed area of 50,000 ha)	28 supplementary sites, 16 trap sites
Groundwater – Baseline	15 compliance bores	11 bores	29 recent utilised Arrow bores, 26 additional proposed bores	22 bores
Surface water – Baseline	1 newly installed ISDS monitoring station, 26 monitoring sites	8 monitoring sites	16 monitoring sites	11 monitoring locations
Soil – Baseline	Field campaign: 17 days 57 samples	Field campaign: 7 days 116 samples	Field campaign: 7 days 271 samples	Field campaign: 6 days 50 samples

Based on EIS review, feedback from proponents and stakeholder engagement, the following assumptions were used for estimating the value (cost) of collected data.

Air quality baseline survey

For the EIS that were selected for review, the air quality baseline surveys were based on existing air quality monitoring sites, operated by DES and/or operated by project proponents. No new monitoring sites were installed in the context of these reviewed EIS, thus no monetary value could be attributed to air quality data collection as part of the review of EIS information.

There is large variation in the cost of air quality monitoring systems as there are a range of sensors and suppliers and a large proportion of the cost is related to ongoing maintenance. Whilst there are sensors as cheap as $300, sensors that are selected for automatic air quality monitoring cost a minimum of $10k. It is difficult to estimate how many sensors would be required for a new monitoring system, as it would depend on the extent of the zone of influence of the project and the objectives of the monitoring. For completeness, we can estimate the cost of air quality data collection at about $50k, which would cover installation of one or several sensors and maintenance for two years.

Flora baseline survey

The survey conducted for the Arrow Bowen Gas Project cost A$1 million but it was a very large survey with 630 locations. The number of locations for the other EIS examined in this study was much lower (38 to 227). Based on this, a ‘standard’ flora baseline survey was estimated in this study to cost between $250k to $500k.

Fauna baseline survey

Similarly to the flora assessment, the survey conducted for the Arrow Bowen Gas Project cost A$1 million but it was a very large survey with 334 locations and 39 trap sites. The number of locations and trap sites for the other EIS examined in this study was lower (Table 2) Based on this, a ‘standard’ fauna baseline survey was estimated in this study to cost between $250k to $500k.

Groundwater baseline survey

The estimated cost of collecting groundwater data is based on:

- Number of new groundwater monitoring bores: this will vary with each project but the average number across the 4 reviewed EIS is 26 new bores. This average is heavily influenced by the Arrow Bowen Gas project, which included a high number of groundwater bores. Based on the authors

experience a standard project in the Bowen Basin is more likely to require around 10 new groundwater bores.

- Bore construction costs: this will vary with the depth of the bores. Construction of reasonably shallow bores in alluvial aquifers would cost around A$50k but deeper bores can cost up to $200k. An average cost of $A100 was adopted in this study.
- Number of monitoring bores that can be accessed in one day: 5 locations per day (based on the authors experience with collecting field data from groundwater monitoring bores), with one sample collected from each bore.
- Number of sampling campaigns: 2.
- Sample analysis for standard analytes: A$1.5k per sample (based on the authors experience with purchasing range of physical and chemical laboratory analyses).
- Labour costs: A$2k per day.

With these assumptions, a 'standard' groundwater baseline survey was estimated in this study to cost A$1 m.

Surface Water baseline survey

Excluding consideration of the installation of monitoring equipment, cost of surface water data collection is based on:

- Number of monitoring sites: this will vary with each project but the average number across the 4 reviewed EIS is 15 locations per project.
- Number of sites that can be accessed in one day: 5 locations per day (based on the authors experience with collecting field data form water monitoring stations), with one sample collected at each location.
- Number of sampling campaigns: 2 (e.g., summer and winter).
- Sample analysis for standard analytes: A$1.5k per sample (based on the authors experience with purchasing range of physical and chemical laboratory analyses).
- Labour costs: A$2k per day.

With these assumptions, a 'standard' surface water baseline survey was estimated in this study to cost ~A$60k.

Soil baseline survey

All four reviewed EIS generated new soil data by undertaking field work and collecting soil samples, and conducting analysis of chemical and physical properties of the collected soil samples. The cost of soil data collection is thus dictated by the amount of time spent in the field and the number of soil samples that were collected and analysed. All EIS reports provided detailed information about collection of soil data, which has been compiled in Appendix B. It can be summarised as follows:

- One field work campaign lasted 6 days, two lasted 7 days and one 17 days: it can be assumed that a 7 day-long field campaign would meet the requirements of many EIS. With a labour cost of A$2k per day, this would cost A$14k.
- The number of collected soil samples varied between 50 and 271, with the associated cost of analysis varying between A$4k and A$30k. The average cost of analysis was A$12.5k.

With this information, a 'standard' soil survey was estimated to cost ~A$30k.

These costs are only an estimate that can be used to evaluate the value of data that will be collected by future EIS projects. As mentioned previously, exact costs will be dictated by the specific objectives of the EIS. The review did show that for some projects, expenditure could be higher. For example, the flora and fauna baseline assessment surveys conducted for the Arrow Bowen Gas project were valued at $1 m for each (Arrow Energy Ltd.). The groundwater surveys, which involved drilling campaigns, data collection and modelling were valued in the millions as well (Resource Strategies Ltd,).

The estimated total costs in this study ($1.64–2.14M) for environmental components in the resource sector EIS submission can be found in Table 4. For completeness, we included a component related to air quality monitoring but this should only be interpreted as a 'groundwater data collection represents the highest costs in EIS submissions (49–64%) and there should be a strong focus on ensuring the data sets are collected and accessible in data management systems.

Table 4: Estimated percentage costs of environmental components in EIS in Bowen Basin.

TOPIC	COST (LOWER ESTIMATE)	COST (LOWER ESTIMATE) AS% TOTAL	COST (HIGHER ESTIMATE)	COST (HIGHER ESTIMATE) AS% TOTAL
Air	$50k	3%	50k$	2%
Flora	$250k	15%	$500k	23%
Fauna	$250k	15%	$500k	23%
Groundwater	$1000k	61%	$1000k	48%
Surface water	$60k	4%	$60k	3%
Soil	$30k	2%	$30k	1%
Total	**$1640k**		**$2140k**	

5.2 Cost of future EIS data collection

If the cost of data collection for one EIS is within the range of $1.6–2.1 million dollars, we can estimate the cost of data collection for all EIS that will be undertaken in the future.

To estimate the number of EIS that will be undertaken, we reviewed the number of EIS that have been submitted in the past. The DES and Coordinator General websites publish the number of completed EIS assessments in Queensland over the last 20 years, which we compiled in Figure 11. Note that the data include approved and rejected assessments. Over the last 20 years, the average number of submitted EIS was 6 per year. It can be assumed that in the future, this submission rate will be similar and that the cost of data collection, as part of EIS preparation and submission, will be in the range of $10–13 million per year. Cumulatively, the value of EIS data generated in Queensland in the last 20 years is estimated at around a quarter of a billion dollars, excluding data modelling and reporting. The EIS datasets have high monetary value and capturing them in Queensland data repositories would ensure that value is not lost.

DES also publishes statistics related to EIS submissions, available at:

https://www.qld.gov.au/environment/pollution/management/eis-process/projects/eis-statistics

The information contains the duration during which the EIS was (1) being undertaken or revised by the proponents, (2) being assessed by DES and (3) submitted for public consultation (Figure 12). This shows that EIS assessments have an average processing timeframe of 2.5 years, with nearly 70% of this time used by the proponents and service providers to generate data, models and reports. If data were collected in central repositories, proponents might be able to reduce this timeframe.

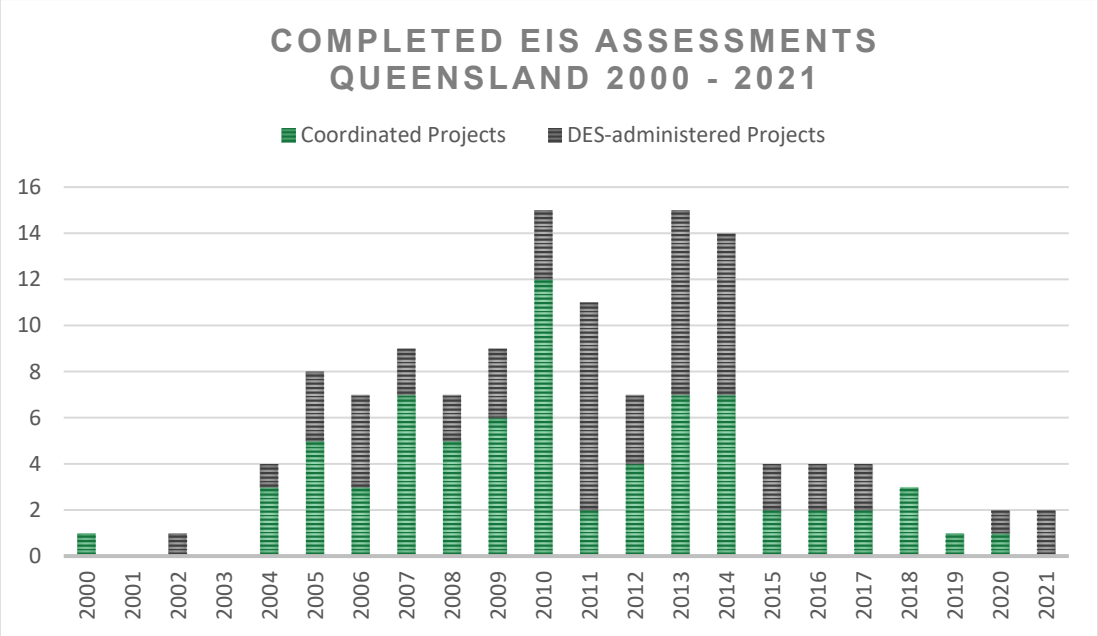


Figure 11: Completed EIS assessments in Queensland over the last 20 years. Data compiled from Coordinator General website and DES website. Data include approved and rejected assessments.

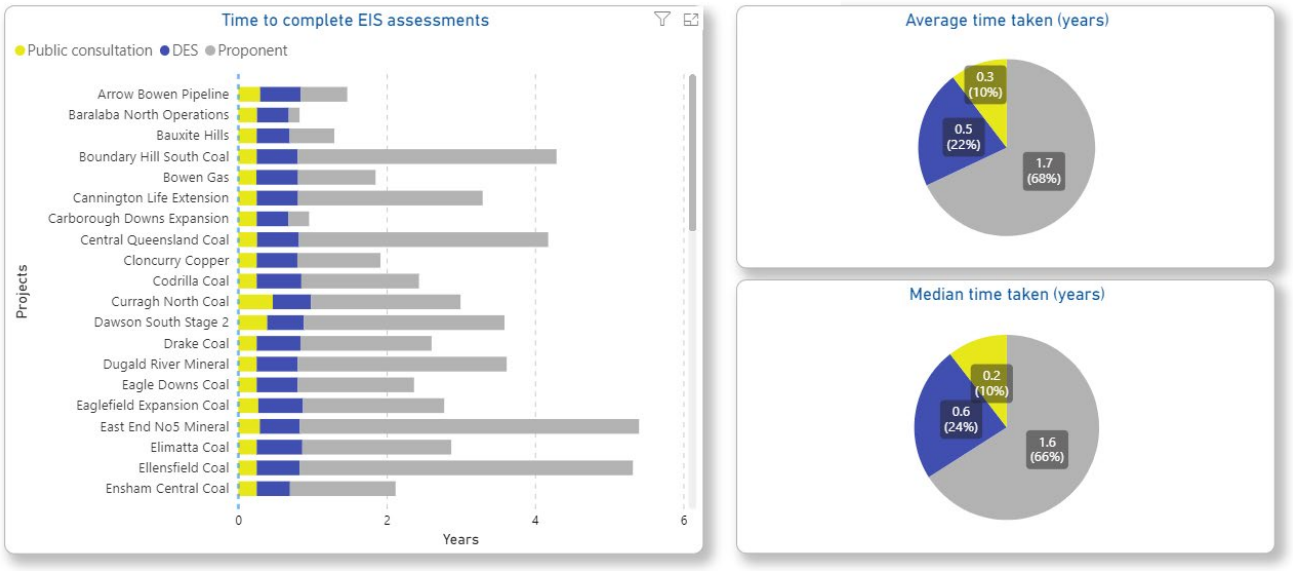


Figure 12: Completed EIS statistics from DES website, highlighting duration for each part of EIS submission (proponents' activities, DES assessment, public consultation).

Compiling data collected as part of EIS will strengthen the Queensland data repositories but will also provide clear benefits to future proponents:

- They might be able to reduce the cost of data collection.
- They might be able to reduce the duration of the EIS as 70% of that duration is related to data collection processes.

Adding data collected by EIS proponents present a clear advantage to regulators as it will contribute to development of improved regional models and assessment of cumulative impacts. It will also present clear advantages to proponents, as it will help reduce EIS timeframes and budget.

The stakeholder engagement conducted as part of this study (Section 4.3) showed that industry representatives held the view that submission of datasets to Queensland repositories would require updates

to the legislative framework to ensure compliance with data submission formats, models and data validation processes. Being able to communicate to proponents the advantages of such data submission processes will assist with the required legal updates.

5.3 Benefits

5.3.1 Contributions to SAFE

The tiers from the SAFE framework that are relevant to this review are Culture, Collect and Curate (Figure 1). Findings from the EIS review were captured for each major data aspect (Biodiversity, Surface water, Groundwater) within each of the relevant SAFE tier (Figure 13).

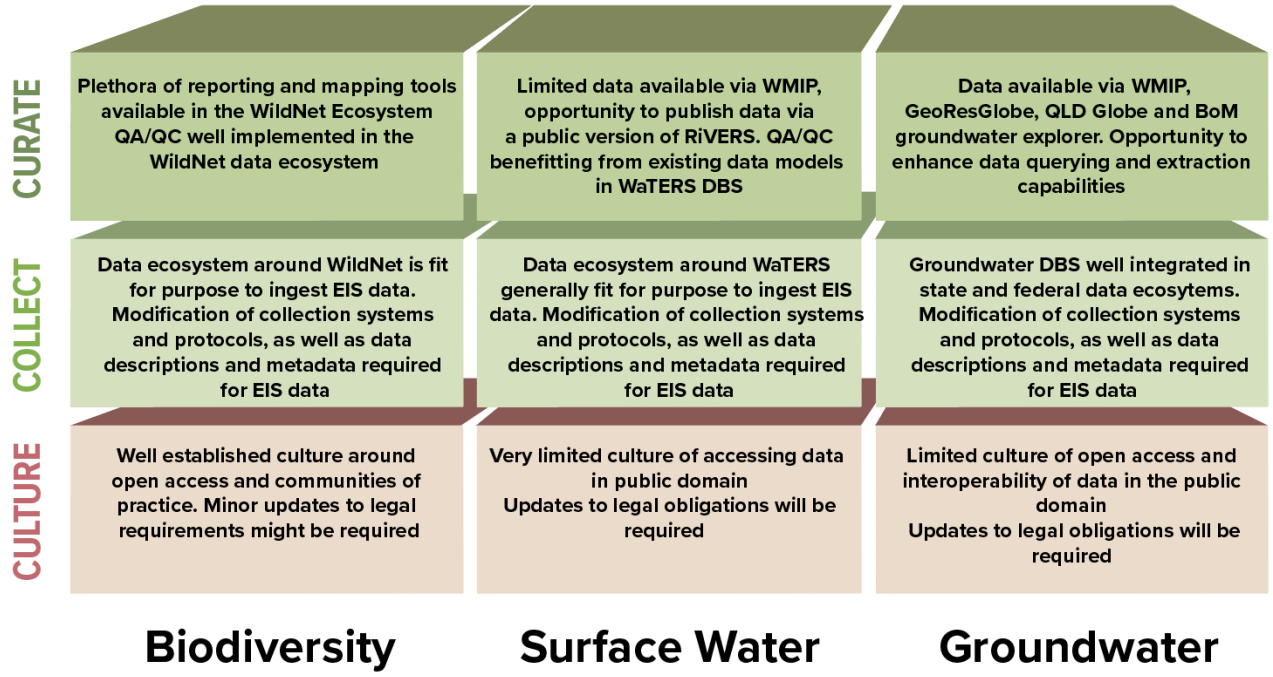


Figure 13: Status of SAFE tiers Culture, Collect and Curation in the context of the three major biophysical aspects.

Once the datasets are captured in systems, they will be available to support projects and bioregional assessments. However, it can be envisaged that they will be used for other purposes, such as regional strategic planning and decision making, Government reporting (such as State of the Environment), public transparency and research activities.

Regarding Culture and associated requirement for updates to legal obligations, it is likely that data submission will need to be supported by legislative changes. Stakeholder feedback was that submission of data collected by proponents would need to become a compliance requirement. This will introduce complexities in reconciling the SAFE approach with current legal obligations and associated data submission practices and vocabulary. There can also be disparities in the interpretation of data submission requirements, with proponents submitting various levels of details. One example is submission of fauna data, with some proponents only submitting information about fauna that were handled, and others providing observational data, such as number of sightings. Any update to legal obligations should seek to address inconsistencies within current practices. There will also be the need to clearly articulate the purpose of each data submission process, such as 'compliance with existing obligations', or 'submission of data from project studies'. These aspects can be addressed with development of detailed data models, as discussed in Section 6.

5.3.2 Data value

Beyond the estimated costs of the data collection, there are differences in the value of the data sets to regional environmental assessments, and in the ability of these data sets to support identification of pressure on related environmental values.

The biodiversity data that are collected through the flora and fauna surveys are highly specific to the proposed tenure boundaries. The feedback that was received from some stakeholders is that these high-resolution flora and fauna assessments might have limited applicability at regional scale but are still valuable to consider potential impacts at local scale (e.g., for areas located immediately around the tenure). Feedback from some proponents was that the data they had collected would not represent high value to regional assessment and that they potentially had limited ability to support identification of pressure on regional values. This would need to be tested in the context of regional datasets.

The data collected as part of groundwater and surface water monitoring campaigns could benefit regional environmental data assessments. This is related to the scale of hydrological and hydrogeological processes, which span large catchments and hydro-geological units. Understanding of these processes is based on developing conceptual and numerical models that are supported and strengthened by regional data collection.

Much of the Bowen Basin is arid or semi-arid (Worden et al., 2021), conditions typically much harder to model than humid temperate catchments (Silberstein, 2006). In arid or semi-arid catchments, the ratio of rainfall to potential evaporation is much less than 1 and under natural vegetation, the average annual streamflow tends to be less than 10% of rainfall. Flow statistics are very difficult to derive, as most of the time, the flow may be zero. Such catchments are difficult to model because the primary drivers of streamflow are the residual of evaporation losses and changes in soil moisture storage, and soil characteristics that control moisture redistribution. With fewer flow statistics, because of fewer days of flow, parameter estimation is much more difficult. Because of the high evaporation, the catchment spends a large proportion of the time with soil moisture either too low for streamflow generation or distributed such that discharge does not occur. Either way, a zero hydrograph gives no information about the water storage or the redistributions that may be taking place. With evaporation being 90% or more of rainfall, a 10% error in its estimation leads to 100% error in streamflow (Silberstein, 2006). As such, whilst hydrological modelling is undertaken with good intentions, data are critical to constrain the discussion and improve the understanding and limitations of the results. Whilst the monetary value of the collected surface data is not large, the data sets have enormous scientific value to strengthen our understanding of Bowen Basin catchments, but also of arid and semi-arid catchments in general.

In addition, the Commonwealth and Queensland regulators will seek advice from the Independent Expert Scientific Committee on Coal Seam Gas and Large Mining Development (IESC) at appropriate stages for the assessment process. In providing advice, the IESC will consider whether a proponent's environmental assessment documentation has:

- used suitable data and information to identify and characterise all relevant water resources and water-related assets.
- applied appropriate methods and interpreted model outputs in a logical and reasonable way to investigate the risks to those assets from the proposed project.
- considered potential cumulative impacts from past, present and other reasonably foreseeable actions.
- adequately described appropriate avoidance or mitigation strategies to avoid or reduce potential impacts to water resources.

- proposed effective monitoring and management to detect and ameliorate the risk of potential impacts, and to assess the effectiveness of proposed mitigation strategies and other management measures.
- addressed the inevitable uncertainties in predictions of potential impacts on water resources and water-related assets.

The documentation provided to the IESC must include the most comprehensive information possible, based on and including all the available data. For example, it should include historical water quality data to demonstrate compliance with existing conditions, bore logs to support geological conceptualisations, and/or the results of pump tests to support model parameterisation. This is particularly relevant for existing CSG and large coal mines undergoing modification/extension or in regions where there are a lot of historical data. Compiling all information in data management systems that can be accessed by the IESC will facilitate development of the advice and will potentially reduce the timeframe to obtain the advice.

6 Recommendations

In Queensland there are well established systems and processes for accessing data, covering biodiversity, groundwater and surface water (Section 3). The corresponding databases that are in the public domain are used extensively by project's proponents and their service providers, demonstrating the value of having such systems in place. There are data held in Queensland government databases that are not accessed by projects' proponents because they are not in the public domain. These relate to water resources, water quality and air quality.

Resource companies collect additional data to support their EIS studies but the clear finding from this study is that these data sets are only available embedded in reports (in pdf format), with no access to the raw data files. These data sets have high monetary and scientific value.

Currently, the existing Queensland databases are not set up to receive these datasets, with one exception (outlined in Section 3): there is an existing pathway to submit survey results associated with biodiversity assessments but it will require further development. There is no existing pathway for submission of groundwater, surface water, soils or air quality data.

There is strong support from industry to gather these data sets, as long as data sharing protocols are clear, 'reasonably' easy to implement and supported by updates to the legislative framework. The main concerns relate to the development of the processes that will support data loading and sharing, particularly in relation to format, quality assurance and validation. This requires 'data models', the suite of protocols that guide data formatting, data validation and quality assurance.

In summary, the main findings in this study are that:

- The exiting data systems in Queensland are equipped to upload and publish data from EIS, but curation systems and catalogues require development (Figure 13, **Curate**).
- Integrating data collected as part of EIS processes into the existing Queensland data infrastructure requires data models that specify minimum requirements for the data, data format, data validation and metadata capture (Figure 13, **Collect**).
- Generally, submission of groundwater and surface water data is not currently included in the Water Act, constraining the data sharing culture on these topics[1]. It is possible that data submission might need to be supported by updates to legislation requiring the reporting of EIS data (Figure 13, **Culture**).
- There are benefits/value to collect and share additional EIS data for most biophysical aspects, including air quality data, but the greatest benefits/value would be from the acquisition of water-related data that is not captured at the moment (Table 2; Section 4).
- The pathways for submitting data are well identified and are provided in the sections below. However, the lines of responsibilities for managing the corresponding databases are not always clear and are in general complex. There is an opportunity to reconsider the structure for the governance of data systems and facilitating access to the Queensland repositories.

[1] There are exceptions: for instance, in the Surat Cumulative Management Area, under the Water Act, CSG and mining activities must submit water-related data to the Office of Groundwater Impact Assessment. The legislative frameworks governing water management are complex and a detailed description was not part of the scope of this project.

6.1 Biodiversity data

6.1.1 Flora and fauna

Data systems around WildNet are well connected within the Queensland data environment and can accept biodiversity data collected as part of EIS processes. It will require development of data models for flora and fauna but there are examples already in place, such as those used by BHP or those proposed by TERN (Guru et al., 2021). It is recommended to review existing models, capitalise on the work already undertaken and adjust it to meet the objective of capturing proponents' data. A robust process for data validation will be critical and for biodiversity data, this is a complex task. This provides a good opportunity to seek to achieve consistency in all data submission processes, including those that already form part of compliance requirements.

6.1.2 Soils

EIS collect soil information that would strengthen the data sets held in QSpatial but there is no process for assessing how data specific to a tenure can contribute to regional maps. This will require research and engagement with the teams responsible for maintaining the soil datasets.

6.2 Surface water

Surface water data are not well integrated into the public domain datasets. WaTERS offers an existing and already commonly used option as a data submission system for EIS data, beyond its current compliance function. WaTERS is currently designed to receive data from existing operations and would need to be updated to receive data from projects (as EIS data are not subject to compliance requirements). This would require a significant investment as the architecture of the database would need to be modified to accept monitoring locations that are not associated with Environmental Authorities.

WaTERS is a commonly used system for collecting surface water data and it should form the basis for any addition to surface water data collection. This will require significant resources. It should also be recognised that the data collected by WaTERS are essentially numeric (flow, concentration in a range of contaminants) and that database development relies on specific data science skills that are not necessarily the same as those associated with developing large spatial datasets. WaTERS needs to be supported by the most appropriate range of scientific and information technology skills. It has the potential to become a leading practice example of surface water data management but would need to be resourced appropriately.

As data related to surface water is generally consistent (location, flow, concentration in a range of contaminants), there should not be any disparity in the interpretation of data submission requirements and achieving consistency in data submission processes should be relatively easy.

There is no existing link between WaTERS and Commonwealth surface water data systems, apart from the Directory of Important Wetlands. Adapting WaTERS and linking it to federal systems may support the IESC activities (Section 5.2.2).

RiVERS is not currently in the public domain, but its inclusion should be considered as it would facilitate research on surface water flow. This will probably require updates to legal obligations, and possibly changes to the Water Act.

6.3 Groundwater

The existing groundwater databases (Section 3.5) could be updated to load the groundwater data generated during EIS studies, from where it can be distributed through the state and federal data systems via existing pathways. There is no requirement for specific infrastructure upgrades, but data models are required. There

are opportunities to improve data querying and extraction and enhance visualisation and analytical capabilities of the mapping tools.

There are existing models for data sharing with BOM leading a number of committees and working groups in collaboration with the States (and other stakeholders). Collectively, they have developed National Water Information Standards for collecting, managing and transferring data. BOM has selected not to issue mandatory standards but instead is working collaboratively with the water industry to develop and promote water information standards and guidelines.

As with surface water data, groundwater datasets should be consistent, with a low risk of disparity in the interpretation of data submission requirements. Achieving consistency in data submission processes should be relatively easy.

6.4 Air quality

Air quality data from monitoring stations installed and operated by industry are not currently captured in the public domain data ecosystem. While some sites are required to provide air quality monitoring data upon request (specified in the respective Environmental Authority), data are not regularly submitted to the authorities. Monitoring data from industry-operated stations could be included in the Live Air Quality application (Section 3.5), provided that data validation and legislation changes are implemented. The legislation changes should focus on the data submission within the framework of the Environmental Authority, because of the importance of time series data for this topic.

However, it should be noted that many of the industry air quality monitoring stations are installed within tenures to assist with managing impacts from activities, such as blasting. They would not contribute much to the understanding and communication of air quality in neighbouring communities. There are examples of monitoring stations that have been installed by industry specifically to produce information about air quality within communities and they are the ones that should be targeted for inclusion in the DES platform. The first action will be to screen all installed stations and assess which ones would contribute the data of most relevance to the platform.

6.5 Data models

The plan to improve data coherence at Queensland and Commonwealth levels that will support data access by a range of stakeholders must include development of consistent data models at state level, which are compatible with federal data systems.

Data model standards should be developed by stakeholders from state and federal government departments in collaboration with industry representatives and service providers. They are the domain experts and are already working with data models for some biophysical aspects, such as biodiversity data. There are examples of effective data models for ecological data (from TERN and BHP). There is a standard for minimum requirement for groundwater data that is currently being developed by the Australian National University in collaboration with the Bureau of Meteorology. DES has recently published a document to guide the use of groundwater monitoring data (DES, 2021b). Other examples include:

- National Water Information Standards, as mentioned above.
- The Australian Geoscience Information Network (AusGIN) Data Standards.
- The new GSQ Open Data portal managed by the Geological Survey of Queensland, used for submission of geoscience data by resource authority holders.

Development of data models should capitalise on the work that has already been undertaken.

6.6 Common public portals

Once there is agreement on data models, data submission can proceed with existing systems. We do not recommend to dramatically change the structure of the systems to enable a single point of EIS data collection. Rather, we suggest investigating the option of a simple common portal where data can be uploaded and from where it can be distributed to the relevant databases. If the process for data submission is difficult to implement, it will act as a disincentive to sharing information, as it will impact on time requirements and resourcing.

Similarly, whilst service providers have sufficient experience to find the relevant public domain data sets, there are opportunities to facilitate access, again by setting up a common portal from which the various databases can be accessed. Figure 10 in Section 3.5 shows an outline of public data repositories and catalogues data and how a common portal could be established.

6.7 Limitations

Whilst this study has focused on articulating the benefits of data sharing, there will be significant challenges to address, including agreement on data models. Detailed analysis of all potential barriers was not part of this project's scope, but it is worth outlining risks associated with:

- Level of available resourcing and funding to support the required improvements and ability for updated systems to adapt to changes in technology.
- Time intervals between data submission and data availability in Queensland systems.
- Lack of supporting contextual information to accompany industry data, which could lead to misinterpretation or misuse.
- Data confidentiality and/or intellectual property conditions.
- Circumstances where it will be difficult to align legal requirements from various jurisdictions.

Finally, it will be important to consider whether data sharing should remain unidirectional (with Queensland systems submitting data to Commonwealth systems) or whether two-way functionality should be considered. For example, the Murray-Darling Basin (MDB) Water Information Portal is managed by BOM with inputs from the States (unidirectional functionality from State to Commonwealth). The WaterInsights Portal is managed by the NSW government with information drawn from drawn from BOM (unidirectional functionality from Commonwealth to State). There are options but they all introduce additional complexity.

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Appendix A

Spreadsheet EIS review (provided as electronic appendix)

Appendix B

Deriving the cost of soil surveys

Site 1: Isaac Down Project

No of Samples:

Sub sample collected down hole from each Site (200 sub samples).

For Laboratory analysis = 25% of total soil samples (200) = 50 subsamples from 12 sites.

Time of sampling:

Time of soil sampling along with soil profile: 6 days.

Cost analysis for Laboratory work:

Table A1: chemical and physical analysis of soil samples.

CHEMICAL ANALYSIS	Electric conductivity (EC)
	pH
	Ca, Mg, Na and P
	Cl, SO_4
	Exchangeable cations
	Cation exchange capacity (CEC)
	Exchangeable sodium percentage (ESP)
	Total N and P
	Organic matter
Lab cost/sample (AUD)	45
Number of samples	50
Total cost for chemical analysis (AUD)	2250
PHYSICAL ANALYSIS	Gravimetric moisture
	Particle size distribution (laser method/hydrometer method)
Lab cost/sample (AUD) × total number of samples	40 × 50
Total cost for physical analysis (AUD)	2000
Total laboratory cost (AUD)	4250

Note: Chemical analysis cost per unit has been obtained from Soil chemical lab at SAFS, UQ. Physical analysis cost per unit has been sourced from soil lab, Ecosciences Precinct Dutton park.

Site 2: Olive Downs Project

No of Samples:

Soil samples were collected from twelve of the detailed sites for laboratory analysis from different depths. However, for each analysis the number of soil samples were different.

Time of sampling:

Time of soil sampling along with soil profile: 6 days.

Detail soil survey: 9 days and 8 days.

Cost analysis for Laboratory work:

Table A2: chemical and physical analysis of soil samples.

CHEMICAL ANALYSIS	Electric conductivity (EC)	Number of samples
	pH	57
	Ca, Mg, Na and P	57
	Cl, SO_4	57
	Exchangeable cations	57
	Cation exchange capacity (CEC)	57
	Exchangeable sodium percentage (ESP)	57
	Available N, extractable P	14
	Organic matter, selected metals, sulfates	14
	Lab cost per sample (AUD)	59
Total cost for chemical analysis (AUD)	**3363**	
PHYSICAL ANALYSIS	Dispersion	
	Particle size distribution (laser method/hydrometer method)	
Lab cost/sample (AUD) × total number of samples	40 × 57	
Total cost for physical analysis (AUD)	2280	
Total laboratory cost (AUD)	5643	

Note: Chemical analysis cost per unit has been obtained from Soil chemical lab at SAFS, UQ. Physical analysis cost per unit has been sourced from soil lab, Ecosciences Precinct Dutton park.

Site 3: Arrow Bowen Gas Project

No of Samples:

Soil profiles were assessed for soil type and distribution, with 15 to 20 samples taken from representative soil pits for laboratory analysis. Total number of 271 soil samples from 16 representative soil profile description sites.

Time of sampling:

Time of soil sampling along with soil profile: 7 days approximately.

Cost analysis for Laboratory work:

Table A3: chemical and physical analysis of soil samples.

CHEMICAL ANALYSIS	Electric conductivity (EC)
	pH
	Ca, Mg, Na and P
	Cl, SO_4
	Exchangeable cations
	Cation exchange capacity (CEC)
	Exchangeable sodium percentage (ESP)
	Available N, extractable P, free and total iron
	Organic matter, selected metals, sulfates
	Micronutrients
Lab cost per sample (AUD)	59
Number of samples	271
Total cost for chemical analysis (AUD)	**16802**
PHYSICAL ANALYSIS	
	Particle size distribution (laser method/hydrometer method)
	Hydraulic conductivity
	Gravimetric moisture
	Colour
	Coarse fragments
Lab cost/sample (AUD) × total number of samples	62 (AUD) × 271
Total cost for physical analysis (AUD)	**14092**
Total laboratory cost (AUD)	30894

Note: Chemical analysis cost per unit has been obtained from Soil chemical lab at SAFS, UQ. Physical analysis cost per unit has been sourced from soil lab, Ecosciences Precinct Dutton park, and CSB soil and plant analysis laboratory.

Site 4: Byerwen Coal Project

No of Samples:

Soil profiles were assessed for soil type and distribution. Soils were collected from 29 soil profiles and from four horizons. Total number of soil samples = 4 × 29 = 116.

Time of sampling:

Time of soil sampling along with soil profile: 7 days approximately.

Cost analysis for Laboratory work:

Table A4: chemical and physical analysis of soil samples.

CHEMICAL ANALYSIS	Electric conductivity (EC)
	pH
	Ca, Mg, Na and P
	Cl, SO_4
	Exchangeable cations
	Cation exchange capacity (CEC)
	Exchangeable sodium percentage (ESP)
	Available N, extractable P, free and total iron
	Organic matter
	Micronutrients
Lab cost per sample (AUD)	45
Number of samples	116
Total cost for chemical analysis (AUD)	**5220**
PHYSICAL ANALYSIS	
	Particle size distribution (laser method/hydrometer method)
	Gravimetric moisture
	Dispersion
Lab cost/sample (AUD) × total number of samples	44 (AUD)x 116
Total cost for physical analysis (AUD)	5110
Total laboratory cost (AUD)	10324

Note: Chemical analysis cost per unit has been obtained from Soil chemical lab at SAFS, UQ. Physical analysis cost per unit has been sourced from soil lab, Ecosciences Precinct Dutton park, and CSB soil and plant analysis laboratory.