Water Data and the Legitimacy Deficit: A Regulatory Review and Nationwide Survey of Challenges Considering Cumulative Environmental Effects of Coal and Coal Seam Gas Developments

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Abstract

Environmental water management in relation to groundwater occurs mainly by controlling groundwater withdrawals under water and environmental assessments and approvals, rather than by actively managing groundwater rights for environmental purposes. Despite apparently close regulation of coal mining and coal seam gas developments, significant public concerns remain regarding the assessment and approval processes that seek to control their cumulative effects on groundwater-dependent ecosystems. This paper analyses a key element of concern: regulatory aspects of water data relevant to assessments and approvals. It outlines a three-part framework for considering requirements for water information in the regulatory context. It then analyses Australian federal legal requirements in relation to water information and data from a new nationwide, exploratory survey of groundwater professionals. Both suggest improved legal measures are required to govern the nature of groundwater data that is produced by governments and proponents, and how and when it is produced.

Keywords: groundwater; law; coal mining; coal seam gas; data; information; legitimacy; water law; environmental law; groundwater-dependent ecosystems

1 Introduction

Information—or more accurately, a lack thereof—lies at the heart of increasing public debates about how Australia regulates the impacts of coal seam gas ('CSG') activities and coal mines (together, referred to here as 'coal seam developments') on the water environment. A central issue is the possible cumulative environmental effects ('CEEs') of these developments—where the overlapping effects of multiple activities can interact and accumulate to create outsized impacts on groundwater resources and groundwater-dependent ecosystems ('GDEs'). In the CSG context, environmental water concerns focus particularly on the ecological impacts of 'associated water' that is carried to the surface alongside gas, potentially reducing the flow of groundwater to dependent wetlands, rivers and springs, and adversely changing conditions for stygofauna living within aquifers (SSCEC 2018). Environmental water management in relation to groundwater occurs mainly by controlling extractions under water and environmental assessments and approvals, rather than by actively managing groundwater entitlements held for environmental purposes (Nelson 2013). Trust in these assessment and approval processes is central to the legitimacy of protections for groundwater environmental management.

This trust appears to be lacking. Despite relatively onerous legal requirements to assess coal seam developments (compared to agriculture, for example) and even some regulatory prohibitions (ACCC 2016), some communities harbour ongoing scepticism and fear (Hunter 2017; Alluvium 2017; Productivity Commission 2017). Numerous state and federal Parliamentary inquiries have investigated coal seam developments, revealing concerns about baseline groundwater data and that of information required to predict the cumulative impacts of developments. (eg SSCEC 2018; SSCUGM 2016; LCEPC 2015; SRATRC 2011). Reported concerns include that the available data is insufficient, biased or otherwise untrustworthy, and that there is insufficient scrutiny of impacts in light of economic incentives for both companies and governments to allow harmful activities (Hunter 2017).

This article analyses one important and often overlooked aspect of the federal regulatory context for coal seam developments and their cumulative impacts on groundwater and GDEs: challenges related to water information. Controversies about mining, groundwater and cumulative impacts represent a 'critical case' of broader concerns about information, water resources and environmental protection colliding. Groundwater is valuable, unseen, subject to low public awareness and understanding and historically low regulatory scrutiny. Its behaviour is scientifically complex and varies significantly across space. Adverse environmental impacts can manifest over long time periods, in some cases, centuries. Groundwater-dependent communities and ecosystems often lack alternative water sources and are vulnerable to its depletion. Groundwater data is expensive and time-consuming to gather and often scarce, with policy exhortations to collect more data extending back decades (ARMCANZ & SCARM 1996, 14). In practice, interpreting groundwater data often involves developer-funded consultants and opaque technical models, which may be viewed with suspicion by the public; and assessing CEEs complicates and amplifies requirements in relation to coordination and data, not to mention modelling resources.

Before questions of interpretation arise, the initial questions—the focus of this paper—remain: do regulatory gaps in relation to water data justify public concerns about the availability of data required for making science-informed decisions? And are there regulatory structures for ensuring the public has evidence about this data? While the further issues of bridging technical and public perceptions about scientific data, and constructing effective participatory processes, lie beyond the regulatory and empirical focus of this paper, a long and rich academic literature in this area (eg Beierle and Cayford 2002; Jasanoff *et al* 1995) points the way to future work to evaluate whether public engagement processes that use data generated through these regulatory structures maximise public legitimacy.

This paper first outlines a simple, three-part framework for considering water information requirements in the regulatory context. It then analyses federal legal requirements[1] and data from a new nationwide, exploratory survey of groundwater professionals. Both suggest that public concern about data deficits may be justified and more refined legal measures are required to govern how and when groundwater information is

[1] Mining or petroleum and gas legislation and environmental legislation also regulate these activities at the state level, but a detailed discussion of these laws is outside the scope of this paper.

produced by governments and proponents ('water information laws'). Two key areas for regulatory refinement emerge: data sharing requirements, and data in relation to GDEs and socio-cultural aspects of water resources.

2 Data Requirements in a Regulatory Context

Lack of scientific information about groundwater presents a critical barrier to environmentally sustainable water management (Caponera 2007; Sax et al, 2006)—a fundamental goal of Australian water law (eg *Water Act 2007* (Cth) s3). Data challenges are also infamous globally in assessing CEEs (eg Ma *et al* 2012, Foley *et al* 2017). Groundwater data support sustainability goals and cumulative effect assessment in three ways in the regulatory context: as background data, project-specific data and assessment, and post-approval data. This Part outlines these three elements before applying them to federal regulation in Part 3.

2.1 Background Regional Groundwater, Ecological and Social Data

Basic frameworks for groundwater monitoring aim to understand conditions and changes in 'regional' groundwater systems, rather than the impacts of a specific project. This involves collecting information about the basic geology, hydrogeology, and groundwater flow systems to guide the establishment of a monitoring network, and defining the relationship between groundwater and surface water (van Lanen and Carillo-Rivera 1998).

'Background' monitoring of water levels and quality, meteorological factors and spring and stream flows, usually at low intensity over large regions, helps to estimate available groundwater resources (van Lanen and Carillo-Rivera 1998). This often involves coordinating the sharing of that information between multiple organisations and requires 'long-term allocation of resources to data collection and analysis' to capture temporal and spatial variability and to avoid discontinuities in observations and inaccurate data (van Lanen and Carillo-Rivera 1998, 12).

Monitoring highly used aquifers can also serve as an 'early warning system' to identify water stress (van Lanen and Carillo-Rivera 1998). Metering in developed aquifers is also crucial: overlooking metering is akin to continually withdrawing money from a bank account without any bookkeeping system (USGS 2003).

In addition to this traditional view of monitoring, ecological data seeks to connect ecological responses to groundwater conditions (Tomlinson 2010). Social and economic issues (including as to Aboriginal cultural objectives) also affect water resources management and require data and consultation (eg Basin Plan 2012 (Cth) ch10 pt14; Hunter 2017, 68).

2.2 Project-level Data: Assessment and Approval

In addition to good raw data about background conditions, water information should also assist decision-making relating to specific proposals that may affect the water environment. In many cases, this involves using data and models to predict how management decisions (for

example, additional pumping) will affect groundwater conditions and GDEs. However, knowledge of groundwater ecological response functions is often sparse (Tomlinson 2011).

Social and economic data at the project assessment stage facilitates understanding the broader significance of predicted changes to groundwater and GDEs. The importance of social and economic data to publicly justifiable decisions about resource extraction is underscored by public controversies in the MDB context, as well as the significant economic value of groundwater-dependent production ($33.8 billion, excluding non-consumptive uses: Deloitte Access Economics 2013).

The presentation of project assessment data should account for public participation in decision-making processes that affect groundwater and GDEs. Such decision-making could involve the public in a variety of ways—from merely being passively informed to being fully in control—represented in various models and typologies (see Reed 2008). 'Legitimacy depends on participation' (Anton and Shelton 2011, 381), and decision-making is 'an intrinsically political process involving community deliberation and struggle', in which science advises but does not dictate (Feldman 1991, 72-73; Lachapelle et al 2003, 475-6). Regardless of the approach to public participation used, public involvement is most valuable if the content of assessments makes transparent the full implications of a proposal, and enables the public to make informed contributions, engage meaningfully and assess factual claims (Fishkin and Luskin 2005). Indeed, many scholars regard adequate scientific information as essential to any approach to public participation (Reed 2008). Knowledge is also the basis for expressing informed consent—a requirement with special meaning for Indigenous Australians (Levy and Orr 2016; MDBA 2017). Where experts disagree—as is not uncommon in relation to interpreting groundwater data, particularly where the complexity of CEEs is concerned—information provided to the public should acknowledge this (Laslett 2003). A further issue, not analysed here, relates to whether the form of scientific information provided to the public (as apart from its content) meets public needs.

2.3 Project-level Data: Post-approval

Water data issues also arise in the post-approval context. Compliance and enforcement activities are challenged by the hidden nature and long timeframes over which impacts manifest in the groundwater context. For both reasons, it may not be immediately obvious if a proponent does not comply with approval conditions, or if unexpected effects occur that vary from those predicted—a particular issue in the context of the high uncertainty associated with predictions of CEEs. Accordingly, reporting of data to government and the public is required to ensure accountability. Public reporting creates 'economic and political incentives' for good management where those objectives would otherwise be frustrated by information asymmetries (Weil et al. 2006, 156), which arise here due to the hidden nature of groundwater and high data collection costs. Recent exposure of wide-scale breaches of water licences has led to recommendations for more data transparency (Matthews 2017), reinforcing the link between transparent post-approval water data and public legitimacy. More positively, publicly disclosing environmental information in a clear, consistent, timely and relevant way can also change proponent behaviour (Fung, Graham, and Weil 2007; Weil et al. 2006).

3 Federal Water Information Laws

Australian policy and law regarding groundwater data have developed substantially in response to public concerns about the CEEs of coal seam developments. While the chief groundwater regulators and data collectors remain Australian states, the federal government plays an increasingly important statutory role in relation to (1) water data generally—producing and collating the background regional data that forms the basis for understanding groundwater systems and GDEs; and (2) specifically in relation to coal seam developments. Yet a legal analysis of these federal laws suggests notable gaps and weaknesses in relation to generating and sharing the information, considered against the three-part framework described above.

3.1 General Water Information Laws

The states' dominant role in water regulation, which is founded for present purposes on licensing extractions, includes allied water information powers. These include estimating or metering licensed extraction (which includes coal seam developments unless they are exempt from licensing requirements), providing for groundwater monitoring wells, producing assessments of water conditions and undertaking water resources planning for regional areas (Gardner et al 2017).

Overlying this state role, the *Water Act 2007* (Cth) ('Water Act') granted the federal government significant nationwide regulatory water information powers and a geographically confined water planning role. The general expansion in federal water information powers rests on a broad definition of 'water information'. It encompasses information about water itself, its economic and supply aspects, rights in relation to it, associated metadata, and 'contextual information' including land use, geological and ecological information (s125). The federal Bureau of Meteorology ('Bureau') is charged with collecting, holding, managing, interpreting and disseminating water information, and also undertaking and commissioning water investigations (s120). The Bureau Director may request water information from a person at any time, and many government entities and a small selection of private power entities[2] must regularly give standardised electronic data to the Bureau (Water Act ss126, 127). The required groundwater information relates to water rights, restrictions on water use, trades, volumes extracted, water quality, water levels, and pressures that the person already holds (Water Regulations 2008 Sch 3). The arrangements do not compel any entity to collect new information (Water Act s126(1)). The major statutory products are National Water Information Standards and a National Water Account that must be 'in a form readily accessible to the public' (Water Act ss122, 123, 130). Similarly, recent major Commonwealth policy-based initiatives relating to groundwater and GDEs have focused

[2] These include State government departments and agencies, local government, water utilities, irrigation districts, and regional natural resources management agencies. Water Regulations 2008 (Cth) rr1.03(1), 7.10; Bureau of Meteorology, Persons and Classes of Persons (2010), http://www.bom.gov.au/water/regulations/schedules/document/Persons_and_Classes_of_Persons.pdf.

largely on collating and digesting existing data, with a notable new initiative being a national GDE Atlas (eg Vertessy 2013; Hoyos 2016; BOM 2015).

The Commonwealth's regulatory water planning role applies to the Murray-Darling Basin ('MDB'), which covers five eastern states and territories, including important coal seam development areas (SRATRC 2011). The Water Act establishes an expertise-based body, the Murray-Darling Basin Authority ('MDBA'), to formulate and recommend to the federal Water Minister legally binding caps on aggregate water (including groundwater) extraction. These limits take effect through an overarching federal Basin Plan, with which subordinate plans formulated by states must comply. Accompanying regulatory information-gathering powers including requesting information and entering private land to measure the condition of GDEs and collect information about water quality and quantity (ss 4(1), 219, 221, 238).

This federal approach to groundwater information is radical and comprehensive in a historical sense (pre-Water Act), but it shows important gaps as regards some aspects of the needs for background data outlined in Part 2.1. It provides for strong powers for agencies to collect information, but private entities are largely overlooked in requirements to provide data regularly, and the full extent of even existing powers is unlikely to be used on account of political sensitivities among the Commonwealth and states. Through the Bureau, it provides a high degree of data consistency and some recognition of the need for publicly accessible dissemination products. However, the approach is under-developed in statute with respect to both collecting and also disseminating 'contextual information', particularly ecological and socio-cultural information beyond market and entitlement information. Neither the National Water Account nor the water information that must be sent to the Bureau must include these types of information (Water Regulations 2008 r7.11, Sch 3). Significant investments in freely available ecological data, like the valuable GDE Atlas, lack the statutory status of the water rights-focused National Account. As a result, decision-makers may overlook them and they risk being insufficiently funded. A centralised database of the environmental water requirements and ecological response models of GDEs could help address a scarcity of data in this area (Tomlinson 2011), and a stronger statutory basis for dissemination products like the GDE Atlas could better ensure their continuation.

3.2 Water Information Laws for Coal Seam Developments

Whereas the Water Act provides for data about groundwater and GDEs in the general context, federal environmental impact assessment legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) ('EPBC Act'), deals with data in the specific context of coal seam developments. This section outlines how legal provisions in relation to water data apply at each of the background, project assessment and post-approval stages. It also summarises key criticisms revealed by a recent formal review into these provisions (the 'Hunter Review': 2017). The prominence of water data issues is reflected in the striking fact that five of the Hunter Review's six recommendations highlighted weaknesses or gaps relating to legal mechanisms for water information. No government response to the Hunter Review had been released at the time of writing.

3.2.1 Regional Groundwater and Ecological Data

Recognising the significance of coal seam developments and their potential for CEEs at a regional scale, a program of initially policy-based 'bioregional assessments' commenced in 2012. The overall aim was to 'strengthen the regulation of [coal seam developments] by ensuring that future decisions are informed by substantially improved science and independent expert advice', with the intended outcome that 'well informed communities have greater confidence in … regulation' (Australian Government 2016, cl11). Bioregional assessments scientifically analyse 'areas with commercially viable CSG and coal reserves' in relation to 'ecology, hydrology and geology … with explicit reference to an assessment of the potential direct and indirect impacts of CSG and coal mining developments on water resources' (Australian Government 2016, cl36(g)). 2013 amendments to the EPBC Act gave bioregional assessments statutory form, and required the Environment Minister to consider them in the context of project assessments. Bioregional assessments[3] have received little scholarly consideration and only some use by the IESC, since individual development proposals have been assessed before the release of the relevant bioregional assessment. The Hunter Review considered this a 'practical approach', but recommended identifying ongoing arrangements for maintaining and funding bioregional assessments (Hunter 2017, 8-10, 61).

3.2.2 Project-level Data: Assessment and Approval

The same rapid policy-to-statute transformation applied to arrangements for assessing coal seam developments. Concerns about the independence of groundwater impact modelling for these developments led to the initial establishment in policy, then in 2013 in statute, of an expert advisory body. The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development ('IESC') advises Ministers on environmental approvals for these developments (EPBC Act s505D, 528). Approvals are required if a development is likely to have a 'significant impact' on 'a water resource' anywhere in Australia, either individually or cumulatively (s 24D, EPBC Act). The IESC was intended to 'provide local communities and other stakeholders with accessible and reliable scientific information that will build confidence in government assessment processes' and 'confidence that projects will be subject to the most rigorous and objective scientific assessment'.[4] Ecological expertise is sufficient, but not required for membership of the IESC (EPBC Act s505C). Social and cultural expertise receive no statutory mention in relation to the IESC. This is despite formal government policy guidance recognising that the social and cultural 'values of a water resource' affect whether a coal seam development triggers the key legal threshold of 'significant impact' (Australian Government 2013). A statutory Indigenous Advisory Committee under the EPBC Act (s505A) has no specific role in relation to coal seam

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[3] See http://www.bioregionalassessments.gov.au/.

[4] House of Representatives Hansard, Second Reading Speech (Tony Burke), Environment Protection and Biodiversity Conservation Amendment (Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development) Bill 2012, 22 March 2012, pp 3956-7.

developments and its bulletins record no related discussions (Australian Government Department of Environment and Energy undated).

Though the IESC provides extensive, valuable, and publicly available advice in relation to specific projects,[5] submissions to a formal review of the amendments ('Hunter Review') suggested important weaknesses related to data and scrutiny of data at the assessment stage. The adequacy of proponent information provided for assessments tends to vary, despite information guidelines to proponents; IESC review timelines are very tight; and the Minister lacks any requirement to follow or even respond to the IESC's advice (Hunter 2017, 54). 'Interested individuals and landowners' surveyed for the Hunter Review 'generally … did not think the water trigger has been beneficial in providing environmental outcomes, [or] community confidence in the regulatory system of applying science to decision-making' (Hunter 2017, 55). These findings led to some recommendations to strengthen arrangements for data and data scrutiny at the assessment stage, namely (1) more clearly documenting government responses to IESC advice; (2) (to the IESC) engaging with industry regarding its scientific methodology and approach; and (3) (to proponents and the IESC) more clearly outlining environmental protections in information supporting assessments (Hunter 2017, 8-10).

3.2.3 Project-level Data: Post-approval

The Hunter Review also uncovered weaknesses related to data and public confidence in the post-approval context. Positively, it found two information-practices that 'increase[] the prospect of public confidence in the regulatory system', being conditions applied to approvals directed at 'enhancing the information and scientific knowledge base to support adaptive management of … developments', and conditions requiring publication of water management plans and monitoring results (Hunter 2017, 6-8, 27-31, 38). However, it did not appear to analyse whether the form of this data meets public participation requirements (see Part 2.2 above), and its conclusion in relation to public confidence appears derived from theory rather than empirical evidence. It formally recommended further review to thoroughly assess the effectiveness of information-related approval conditions and compliance with them (Hunter 2017, 8-10).

The legal analysis in this Part suggests that federal water information laws—both general and specific to coal seam development—have, on their face, significant strong points, and, in practice, notable apparent weaknesses when analysed against the framework in Part 2. Strengths lay in formidable federal powers to collect and require certain persons to provide existing water data; statutory bioregional assessments; formal independent scrutiny of the use of water data at the assessment stage; and the use of post-approval conditions to generate important data that could positively influence public confidence. Apparent weaknesses were the limited use of certain federal data collection powers in relation to ecological and social/cultural data, a lack of statutory basis (and therefore, security) for valuable public

[5] See http://www.iesc.environment.gov.au/committee-advice/proposals.

dissemination products like the GDE Atlas; the funding insecurity of bioregional assessments and their incomplete nature; submission of variably sufficient assessment data by proponents; an uncertain level of Ministerial follow-up to formal advice; a lack of clarity about whether the form of key information products (like bioregional assessments) meet public needs, and uncertain levels of compliance with approval conditions related to water data.

4 An Empirical View of the Data Deficit

Globally, cumulative effect assessment is known to suffer data problems in many natural resources contexts, and surveys have commonly been used to investigate these issues (Cooper and Canter 1997, Foley *et al* 2017, Ma *et al* 2012). However, little scholarly work has analysed the challenges that practitioners experience in practice in considering CEEs in the groundwater context, and the extent to which water data and links with law present challenges and potential solutions. These links between law and data speak to whether regulatory gaps relating to the generation and availability of water data might justifiably fuel public concerns about the use of science in groundwater-related decision-making processes. This survey is a first attempt to explore these general challenges relating to groundwater. Its results confirm and extend the observations in the foregoing legal analysis and the Hunter Review and point to specific opportunities for further regulatory development.

4.1 Methodology

The author surveyed[6] the registrants of a lecture sponsored by two groundwater science-focused organisations and delivered by the author in nine major Australian cities across every State and Territory in late 2016.[7] This nonrandom sampling approach is appropriate for an exploratory survey, and the study does not attempt to draw any related statistical generalisations (Hibberts *et al* 2012). The 102 participants (31% response rate) played various roles relating to approval processes for developments: government agency official; project/development proponent or consultant to a proponent; third party or consultant to a third party (eg non-government organisation, community group, etc); and other. These are termed ‘Agency’, ‘Proponent’, ‘Third party’ and ‘Other’ in the text below, with quotes anonymised and attributed to participants as [‘role’]. The survey was piloted as a paper form distributed to self-selected participants after the first lecture (6 responses), then distributed electronically with no changes to registrants of all lectures in December 2016 (96 responses). The total number of responses compares favourably to the number included in past surveys (Cooper and Canter 1997: n = 25, Foley *et al* 2017: n = 54, Ma *et al* 2012: n = 38).

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[6] Approved by the Human Research Ethics Committee of The University of Melbourne, HREC 1648051.1.

[7] International Association of Hydrogeologists (Australia)/National Centre for Groundwater Research and Training Distinguished Lecture, ‘Regulating the Cumulative Impacts of Groundwater Withdrawals: Australia and Further Afield’, delivered in Melbourne, Sydney, Canberra, Brisbane, Townsville, Perth, Adelaide, Darwin, and Hobart from Oct-Dec 2016.

The survey comprised open-ended questions about challenges experienced by participants in considering CEEs. The survey asked respondents to describe 'the three most important challenges involved in considering the cumulative impacts of development activity on natural resources' and to give supporting reasons. Finally, participants were asked to describe 'what would help to address these challenges'. Survey results are presented using two units of analysis: challenge, and participant (ie encompassing multiple challenges that a participant identified). Each challenge and its accompanying reason were coded for up to two themes. Codes were first formulated inductively, then applied to all responses with iterative development and consolidation of themes as required (see also Supplementary Materials).

Although the relevant lecture dealt with the same general subject matter as the questionnaire, the former is considered unlikely to significantly influence responses, since the survey questions and responses focused on participants' own experiences. In addition, in most cases (96/102) the respondent completed the questionnaire multiple weeks after the lecture, with reduced recall expected to lower any effect of the lecture on responses.

4.2 Results and Discussion

4.2.1 Characteristics of participants

Participants represented all roles in approval processes: government (65%); proponent (34%); third party (24%); other (2%); with some participants having no direct experience of approval processes (7%). 29% of participants nominated multiple roles. Of participants with experience in approvals processes, 23% had experience relating to the water trigger, and 81% had experience with other natural resources approvals processes (primarily Australian state water licensing and water resources planning processes, and approval processes under state environmental and mining legislation).

4.2.2 Major themes of identified challenges

Participants nominated 287 individual challenges, which were coded into nine themes (Table 1). Three themes dominated (shaded rows, Table 1), each applying to greater than 25% of the identified challenges, and appearing in over 50% of participants' responses. Challenges relating to availability and sharing of 'raw' data accounted for 36% of challenges, and was the most common issue raised by participants (68% of participants). Challenges in assessing and modelling impacts (ie creating predictive data from 'raw' data to guide decisions) accounted for 26% of challenges, and appeared in 54% of participants' responses. 80% of participants nominated at least one challenge in one of these major information-related categories.

Table 1. Major Themes of Challenges Identified by Participants

	Consolidated themes	# challenges coded at this theme	% of challenges coded at this theme	% of participants mentioning this challenge theme[8]
Technical themes	**Data availability and sharing**	104	36%	68%
	Assessing/ modelling	74	26%	54%
	Monitoring	14	5%	13%
	Any technical theme	192	67%	**80%**
Social/ institutional themes	**Law/ regulation/ policy**	86	30%	60%
	Allocating responsibility	21	7%	17%
	Political/ attitudinal	40	14%	32%
	Public awareness	8	3%	8%
	Other	22	8%	19%
	Any social/institutional theme	133	46%	**75%**
Cross-cutting theme	**Resource protection and setting limits**	32	11%	24%

4.2.2.1 Information-related challenges: data availability, data sharing and baseline data.
The high frequency of identifying information-related challenges is not surprising given the scientific organisational sponsors and expected scientific background of the participants. However, it is instructive to consider the specific nature of the information-related challenges identified. These related to data availability (referring to a lack of data without specific reference to its type or the reason for its absence), data sharing (referring to project proponents being unwilling to share data with other proponents, government agencies or the public), and baseline data (referring to a lack of this specific kind of data). Table 2 gives two representative responses for each sub-category, representing different participant roles. Participants' stated reasons for nominating data-related challenges often related to consequences for being able to make 'informed' decisions with sufficient 'evidence' or undertake 'meaningful consideration' of a proposal. The survey reinforces that inadequate data and technical assessment processes may lead to decisions that lack legitimacy in the eyes of a technically literate audience (noting that surveying a non-technical audience would be

[8] Note that the figures for %participants for each 'technical theme' do not add to the total for %participants for all technical themes because a single participant may have identified between 1 and 3 challenges within each theme. Similarly, figures for #challenges and %challenges do not sum to totals since one challenge can be coded with more than one theme.

required to evaluate the links between data and legitimacy more broadly in the groundwater context).

While the strong focus of the lack of baseline data mirrors concerns evident in formal inquiries about coal seam developments (see above), the survey gives new prominence to problems of data sharing. Improving data sharing would help address issues of insufficient data availability, including as to baseline data, lower costs associated with assessment for proponents ('*help the companies reduce "doubling up" on work*' [Government]), and enable decision-makers to make more informed decisions. Sharing data would also address a perceived lack of transparency in processes for assessing and managing CEEs. That is, sharing data may positively impact public perceptions and confidence, independently of the technical value of the data. Yet, as commonly noted across the data sharing theme, project proponents are unlikely to share data with competitors or government unless compelled to do so. If decision-makers are prepared to approve proposals on current, reportedly low, levels of information, proponents have little incentive to share data to increase collective knowledge. Any potential future mandate to share information should be formulated bearing in mind the effects of communication format and style: *'data sharing and openness about resource monitoring … at the moment is lost in multiple heavy reports to regulators by individual proponents'* [Government].

Table 2. Raw data-related challenges identified by participant role

Data-related challenges	**# & (%) of challenges**	**'*Challenge*': '*supporting reason*' [participant role(s)] (unedited)**
Baseline data	56 (19.5%)	*'Lack of information to define current state to inform vulnerability or limits of acceptable change: Without understanding existing environment, impacts of changes are almost impossible to quantify'* [Government; proponent]
		'Extent of combined existing impact of development (impacts are reported on piecemeal by licensees) and whether these have stabilised or are continuing to expand/magnify: Assessing additional impacts of any new proposal presumes that impacts of existing activities are known and the final level of impact has been reached or is known with confidence. This risk is often carried by states.' [Government]
Data availability generally/ no specific context	23 (8.0%)	*'Data shortages: Without reliable, continuous temporal data, preferably for wet, normal, and dry years, it is very difficult to develop robust and defensible models to support the development of fit for purpose management plans.'* [Government; proponent]
		'Lack of scientific evidence on which to base decisions: Understanding whether cumulative impacts may exist or whether they need to be mitigated is almost impossible without supporting data.' [Government]

Data sharing	24 (8.4%)	*'Obtaining data: Accurate estimates of cumulative impacts require data from often competing industries - this can often be difficult to obtain. Sometimes because the records have not been kept by industries, or that they are unwilling to share records with competitors.'* [Third party]
		'Knowledge of regional system: In general accurate knowledge of hydrogeology (and to a lesser extent hydrology) is confined to clients tenement, with occasional other information available. [The] challenge [is] liaison with adjacent proponents/activities subject to commercial confidentiality interests.' [Proponent; third party]

4.2.2.2 Challenges related to legal, social and institutional matters. Relative to information-related challenges (identified by 80% of participants), the high frequency at which participants identified challenges related to legal, social and institutional matters (75% of participants) is more surprising (although the relevant lecture and reference to 'regulating' in the survey's explanatory material may have inflated this frequency). Broadly, challenges concerned issues that were not specific to a particular law or jurisdiction (especially incorporating community concerns in decision-making, inter-jurisdictional regulatory differences, appropriate policy weighting between economic and environmental concerns, and appropriate enforcement post-approval) as well as more specific challenges related to particular development stages (eg insufficient regulation post-closure) or specific water laws.

With respect to allied social/institutional themes (Table 1), 'responsibility' challenges related to concerns about equity or lack of clarity in allocating responsibility for collecting data, undertaking monitoring or modelling or managing/mitigating impacts between project developers, or between developers and government. 'Political/attitudinal' and 'Public awareness' challenges covered a mismatch between science or data availability and politics or public perceptions (eg *'Political imperatives have the potential to impact the objectivity of assessment and approval processes'* [Government]; *'There is a lot of misinformation in the public space regarding groundwater and how it may be impacted. It is such an emotive issue that it is very easy for opponents to developments to oppose development based on very little scientific facts or evidence.'* [Government/Third party]); *'Any discussion undertaken in a knowledge vacuum will inevitably be won by the most influential or powerful party, rather than being based on a logical process using appropriate knowledge, agreed aims and principles.'* [Government/Third party]). Responses also pointed to political/attitudinal factors that constrained action justified by data *('Having the courage to back the data that has been provided so that the resource can be managed in a sustainable way'* [Government]; *'Once the science is done to their best ability with VERY [sic] short timeframes, the politics comes in and adjusts the outcomes'* [Government]). 'Other' challenges often related to insufficient resources or technical skills for assessment and review.

4.2.2.3 Links between legal/institutional and information-related matters. Concerns about data significantly overlapped with identified solutions relating to law, regulation or policy with 26% of suggested solutions suggesting a role for the latter in solving problems relating to data. Representative examples include suggesting that regulatory decisions *'should be based on robust data that can be scientifically defended and provide the public confidence that the outcomes can be trusted'* [Government/Third party]; that *'greater co-operation between proponents, possibly overseen/orchestrated by regulators [would] ensure maximum use of available information for cumulative impacts'* [Proponent/Third party]; and that regulations should define *'consistent minimum data requirements to support environmental assessments across all Australian jurisdictions'* [Government/Proponent].

4.2.2.4 Links between information, trust and legitimacy. Taking suggested challenges and solutions together, 25% of participants referred to concepts related to trust and legitimacy, particularly characteristics of data and data-driven decisions that were 'transparent', 'defendable', 'accepted', 'independent', 'objective' and attracted the 'confidence' of the public (and derivative terms). While few participants explicitly identified relevant actors (eg defence from whom and transparent to whom), those that did tended to refer to the 'community', 'public', 'stakeholders', and water 'users'.

V Recommendations and conclusion

Water information is crucial for sustainable management of groundwater, and coal seam developments are a particularly data-hungry and publicly contested locus for examining this need and the adequacy of steps to meet it. Governments openly acknowledge that public concerns about the regulation of coal seam developments and their impacts have scepticism about science and data at their heart, and require better identifying and understanding potential and actual impacts 'through a transparent process that builds public confidence' and 'ensuring that the best scientific information … underpins all relevant regulatory processes and decisions' (National Partnership Agreement 2012, cl 3, 4).

On the face of the law, coal seam developments receive a higher level of regulatory scrutiny than that of other developments that may have similar effects on groundwater and GDEs, for example agriculture or other types of mining, which are not caught by federal assessment and approval requirements in relation to impacts on water resources. Yet current levels of public confidence, and the legal and survey analysis given here suggest that the water data-related elements of this scrutiny could be improved, both on the face of the law and in practice. Indeed, governments themselves acknowledge that water data requires improvement and that this is vital to both 'ensuring sustainability' and 'building associated public confidence and acceptance of regulation' (Australian Government 2016, 4, 6). This study has noted an ongoing gap in evaluating whether the form in which often complex water information is currently disseminated is appropriate for public audiences, and therefore may effectively address issues of trust and legitimacy. Empirical investigations beyond the practitioner-focused survey reported here could assist such an evaluation.

Two areas emerge as immediate opportunities for federal laws to help to increase the background and project-specific information available to understand and assess CEEs in the context of groundwater generally and coal seam developments in particular:

(1) Extend requirements to share existing data between primarily government and state-owned entities and proponents. This data could be legally and practically integrated into statutory water data products like bioregional assessments and the National Water Accounts, using the existing National Water Information Standards. Requirements could be enforced through project approval conditions or the federal Bureau's power to require entities to provide information to it. This is consistent with national strategy that calls for better use of 'information from private industry datasets (eg. mining)' (Australian Government 2016, 10-11), and with the view in the federal Water Act that commercial sensitivity is not a reasonable excuse for failing to give water information to the federal Bureau (s 127(4)), notwithstanding concerns from practitioners about commercial confidentiality (eg Table 2). This would be an initial step towards better baseline and ongoing information that would not impose higher costs on proponents.

(2) Make more extensive use of 'contextual'—that is, ecological socio-cultural—elements of federal water information laws, for example, representing these uses in National Water Accounts (and considering whether the GDE Atlas should become part of the Accounts) and considering water-related social and cultural expertise in the composition of the IESC. This would support the formal policy link with the 'significant impact' threshold for assessment under the EPBC Act and run parallel to recent federal recognition of cultural water objectives in the MDB. The collection and disclosure of culturally sensitive water information would need to be handled using culturally appropriate protocols for access, precedent for which has been developed in New South Wales (Productivity Commission 2017).

Better water information laws have the potential to address public fears that coal seam developments are being insufficiently regulated and scrutinised. Better water information laws are also consistent with, and arguably required by, the strong focus of modern water and environmental law on public participation. They also support an acknowledged need for greater accountability of proponents and governments in relation to CEEs. Better information requirements in relation to groundwater in the CSG context (where groundwater environmental water protections depend on restrictions on extraction) would appropriately mirror the increased focus on information, monitoring and evaluation in the surface environmental water context of managing environmental flows (Productivity Commission 2017). Proponents, the public and governments would all benefit from efforts to improve the legitimacy and robustness of environmental protections in the groundwater context by ensuring strong regulatory support for informed science in decision-making processes.

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